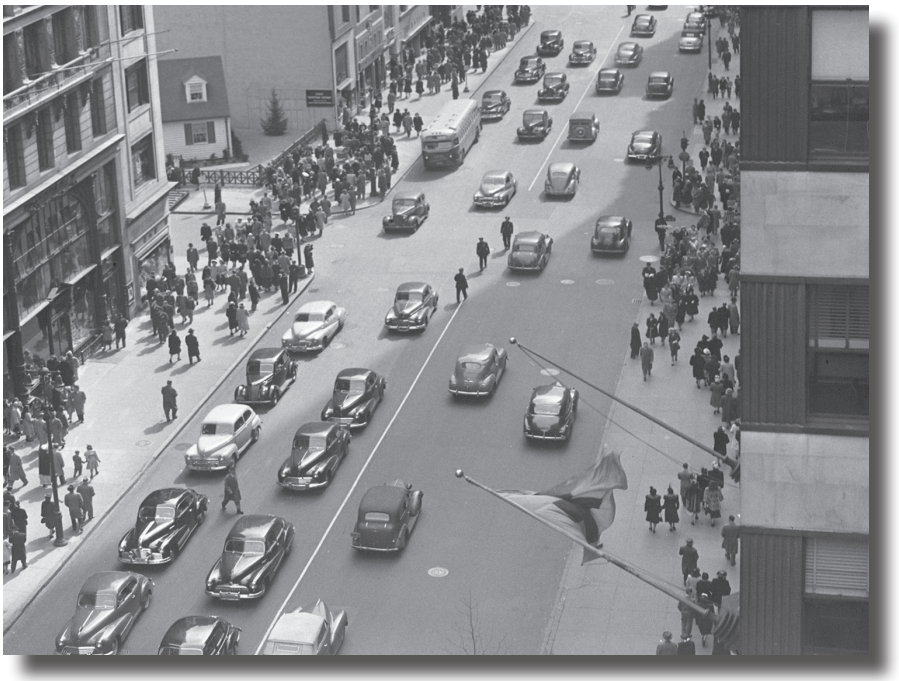
12 advanced object construction

Creating objects



So far we've been crafting objects by hand. For each object, we've used an **object literal** to specify each and every property. That's okay on a small scale, but for serious code we need something better. That's where **object constructors** come in. With constructors we can create objects much more easily, and we can create objects that all adhere to the same **design blueprint**—meaning we can use constructors to ensure each object has the same properties and includes the same methods. And with constructors we can write object code that is much more **concise** and a lot less error prone when we're creating lots of objects. So, let's get started and after this chapter you'll be talking constructors just like you grew up in Objectville.

Creating objects with object literals

So far in this book, you've been using *object literals* to create objects. With an object literal, you create an object by writing it out… well, literally. Like this:

```
var taxi = {
    make: "Webville Motors",
    model: "Taxi",
    year: 1955,
    color: "yellow",
    passengers: 4,
    convertible: false,
    mileage: 281341,
    started: false,

    start: function() { this.started = true;},
    stop: function() { this.started = false;},
    drive: function {
        // drive code here
    }
};
```

With an object literal you type out each part of the object within curly braces. When you're done, the result is an actual JavaScript object, which you typically assign to a variable for later use.

Object literals give you a convenient way to create objects anywhere in your code, but when you need to create lots of objects—say a whole fleet of taxis—you wouldn't want to type in a hundred different object literals now would you?

BRAIN POWER

Think about creating a fleet of taxi objects. What other issues might using object literals cause?

- ☐ Tired fingers from a lot of typing!
- ☐ Can you ensure that each taxi has the same properties? What if you make a mistake or typo, or leave out a property?
- ☐ A lot of object literals means a lot of code. Isn't that going to lead to slow download times for the browser?
- ☐ The code for the start, stop and drive methods would have to be duplicated over and over.
- ☐ What if you decide to add or delete a property (or to change the way start or stop work)? You'd have to make the change in all the taxis.
- ☐ Who needs taxis when we have Uber?

Using conventions for objects

The other thing we've been doing, so far, is creating objects *by convention*. For example, we've been putting properties and methods together and saying "it's a car!" or "it's a dog!", but the only thing that makes two such objects cars (or dogs) is that we've followed our own conventions.

Now, this technique might work on a small scale but it's problematic when we have lots of objects, or even lots of developers working in the same code who might not fully know or follow the conventions.

But don't take our word for it. Take a look at some of the objects we've seen earlier in the book, which we've been told are cars:

This definitely looks like the cars we've been dealing with. It has all the same properties and methods.

```
var taxi = {
    make: "Webville Motors",
    model: "Taxi",
    year: 1955,
    color: "yellow",
    passengers: 4,
    convertible: false,
    mileage: 281341,
    started: false,

    start: function() {
        this.started = true;
    },

    stop: function() {
        this.started
```

The tbird looks like a great car, but we're not seeing some of the basic properties it needs, like mileage or color. It also seems to have a few extra properties. That could be a problem...

```
var tbird = {
    make: "Ford",
    model: "Thunderbird",
    year: 1957,
    passengers: 4,
    convertible: true,
    started: false,
    oilLevel: 1.0,

    start: function() {
        if (oilLevel > .75) {
            this.started = true;
        }
    },

    stop: function() {
        this.started = false;
    },

    drive: function() {
        // drive code here
    }

};
```

Okay, this looks a lot like our other car objects...but wait. This has a rocket thruster. Hmm, not sure this is really a car.

```
var rocketCar = {
    make: "Galaxy",
    model: "4000",
    year: 2001,
    color: "white",
    passengers: 6,
    convertible: false,
    mileage: 60191919,
    started: false,

    start: function() {
        this.started = true;
    },

    stop: function() {
        this.started = false;
    },

    drive: function() {
        // drive code here
    },

    thrust: function(amount) {
        // code for thrust
    }
};
```

```
var toyCar = {
    make: "Mattel",
    model: "PeeWee",
    color: "blue",
    type: "wind up",
    price: "2.99"
};
```

Wait, this might be a car but it looks nothing like our other cars. It does have a make, model and color, but this looks like a toy, not a car. What's this doing here?

If only I could find a way to **create objects** that all share the same basic structure. That way all my objects would look the same by having all the right properties and all my methods would be defined in one place. It would be something like a cookie cutter that just stamps out copies of the object for me. That would be dreamy. But I know it's just a fantasy...

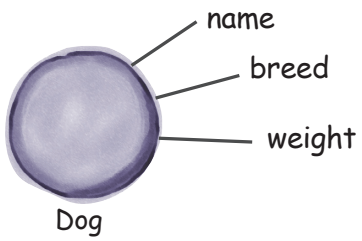
Introducing Object Constructors

Object constructors, or "constructors" for short, are your path to better object creation. Think of a constructor like a little factory that can create an endless number of similar objects.

In terms of code, a constructor is quite similar to a function that returns an object: you define it once and invoke it every time you want to create a new object. But as you'll see there's a little extra that goes into a constructor.

The best way to see how constructors work is to create one. Let's revisit our old friend, the dog object, from earlier in the book and write a constructor to create as many dogs as we need. Here's a version of the dog object we've used before, with a name, a breed and a weight.

Object constructors and functions are closely related. Keep that in mind as you're learning how to write and use constructors.



Now, if we were going to define such a dog with an object literal, it would look like this:

```
var dog = {
    name: "Fido",
    breed: "Mixed",
    weight: 38
};
```

Just a simple dog object created by an object literal. Now we need to figure out how to create a lot of these puppies.

But we don't want *just a Fido* dog, we want a way to create *any dog* that has a name, a breed and a weight. And, again, to do that we're going to write some code that looks like a function, with a dash of object syntax thrown in.

With that introduction, you must be a bit curious—go ahead and turn the page and let's get these constructors figured out and working for us.

How to create a Constructor

Using constructors is a two-step process: first we define a constructor, and then we use it to create objects. Let's first focus on creating a constructor.

What we want is a constructor that we can use to create dogs, and, more specifically, dogs with names, breeds and weights. So, we're going to define a function, called the constructor, that knows how to create dogs. Like this:

A constructor function looks just like a regular function.

But notice that we give the name of the constructor function a capital letter. This isn't required; but everyone does it as a convention.

The parameters of the function match the properties we want to supply for each individual dog.

```
function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
}
```

This part feels more like an object because we're assigning each parameter to what looks like a property.

The property names and parameter names don't have to be the same, but they often are—again, by convention.

Notice that this constructor function doesn't return anything.

Hmm, we're not using local variables like in most functions. Instead we're using the this keyword, and we've only used that inside objects so far.

Hang on; we'll look at how we use the constructor next and then all this is going to fall into place and make more sense.

Sharpen your pencil

We need your help. We've been using object literals to create ducks. Given what you learned above, can you write a constructor to create ducks for us? You'll find one of our object literals below to base your constructor on:

```
var duck = {
    type: "redheaded",
    canFly: true
}
```

Here's an example duck object literal.

Write a constructor for creating ducks.

P.S. We know you haven't fully figured out how this all works yet, so for now concentrate on the syntax.

How to use a Constructor

We said using a constructor is a two-step process: first we create a constructor, then we use it. Well, we've created a Dog constructor, so let's use it. Here's how we do that:

To create a dog, we use the new operator with the constructor.

Followed by a call to the constructor.

And the arguments.

Try saying it out loud: "to create fido, I create a new dog object with the name Fido that is a mixed breed and weighs 38 pounds."

```
var fido = new Dog("Fido", "Mixed", 38);
```

So, to create a new dog object with a name of "Fido", a breed of "Mixed" and a weight of 38, we start with the `new` keyword and follow it by a call to the constructor function with the appropriate arguments. After this statement is evaluated, the variable `fido` will hold a reference to our new dog object.

Now that we have a constructor for dogs, we can keep making them:

```
var fluffy = new Dog("Fluffy", "Poodle", 30);

var spot = new Dog("Spot", "Chihuahua", 10);
```

That's a bit easier than using object literals isn't it? And by creating dog objects this way, we know each dog has the same set of properties: name, breed, and weight.


```
function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
}
var fido = new Dog("Fido", "Mixed", 38);
var fluffy = new Dog("Fluffy", "Poodle", 30);
var spot = new Dog("Spot", "Chihuahua", 10);
var dogs = [fido, fluffy, spot];

for (var i = 0; i < dogs.length; i++) {
    var size = "small";
    if (dogs[i].weight > 10) {
        size = "large";
    }
    console.log("Dog: " + dogs[i].name
                + " is a " + size
                + " " + dogs[i].breed);
}
```

Let's get some quick hands-on experience to help this all sink in. Go ahead and put this code in a page and give it a test drive. Write your output here.

How constructors work

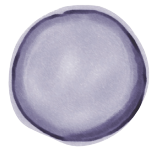
We've seen how to declare a constructor and also how to use it to create objects, but we should also take a look behind the scenes to see how a constructor actually works. Here's the key: to understand constructors we need to know what the `new` operator is doing.

We'll start with the statement we used to create `fido`:

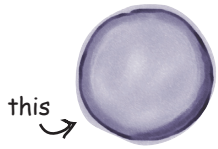
```
var fido = new Dog("Fido", "Mixed", 38);
```

Take a look at the right-hand side of the assignment, where all the action is. Let's follow its execution:

1. The first thing `new` does is create a new, empty object:

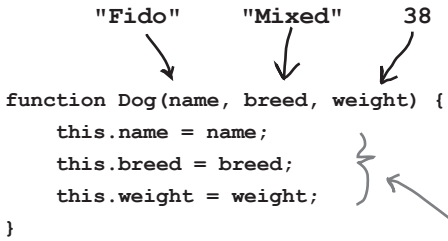


2. Next, `new` sets `this` to point to the new object.

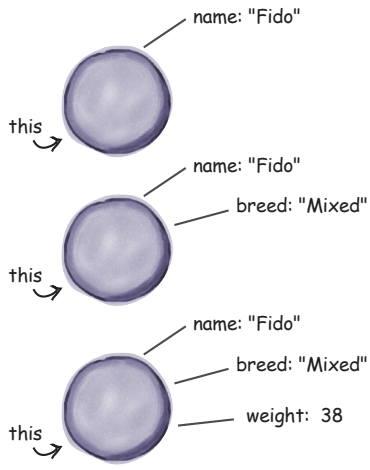


Remember from Chapter 5 that this holds a reference to the current object our code is dealing with.

3. With `this` set up, we now call the function Dog, passing "Fido", "Mixed" and 38 as arguments.



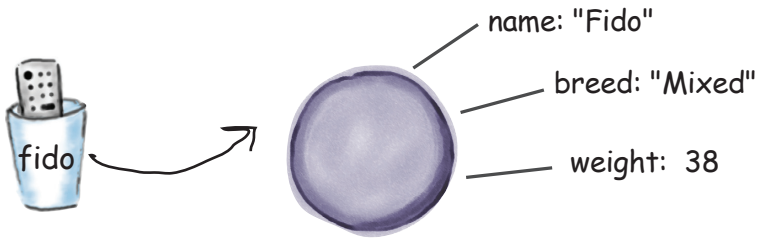
4. Next the body of the function is invoked. Like most constructors, Dog assigns values to properties in the newly created `this` object.



Executing the body of the Dog function customizes the new object with three properties, assigning them the values of the respective parameters.

5 Finally, once the Dog function has completed its execution the `new` operator returns `this`, which is a reference to the newly created object. Notice `this` is returned for you; you don't have to explicitly return it in your code. And after the new object has been returned, we assign that reference to the variable `fido`.

Behind the Scenes



BE the Browser

Below, you'll find JavaScript code with some mistakes in it. Your job is to play like you're the browser and find the errors in the code. After you've done the exercise look at the end of the chapter to see if you found them all. And, hey by the way, this is Chapter 12. Feel free to make style comments too. You've earned the right.

```
function widget(partNo, size) {
    var this.no = partNo;
    var this.breed = size;
}
function FormFactor(material, widget) {
    this.material = material,
    this.widget = widget,
    return this;
}

var widgetA = widget(100, "large");
var widgetB = new widget(101, "small");
var formFactorA = newFormFactor("plastic", widgetA);
var formFactorB = new ForumFactor("metal", widgetB);
```

You can put methods into constructors as well

The dog objects that the Dog constructor creates are just like the dogs from earlier in the book… except that our newly constructed dogs can't bark (because they don't have a `bark` method). This is easily fixed because in addition to assigning values to properties in the constructor, we can set up methods too. Let's extend the code to include a `bark` method:

By the way, as you know, methods in objects are properties too. They just happen to have a function assigned to them.

To add a bark method we simply assign a function, in this case an anonymous function, to the property this.bark.

```
function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.bark = function() {
        if (this.weight > 25) {
            alert(this.name + " says Woof!");
        } else {
            alert(this.name + " says Yip!");
        }
    };
}
```

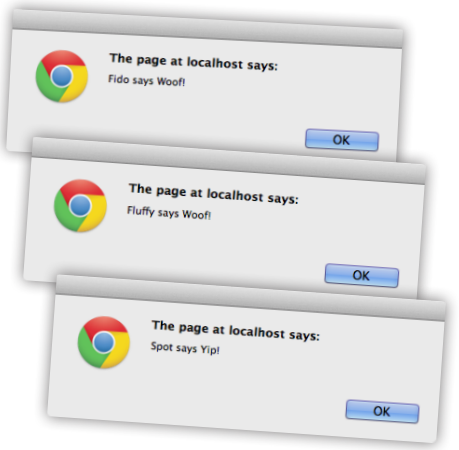
Now every dog object will also have a bark method that you can invoke.

Notice that, just like all the other objects we've created in the past, we use this to refer to the object we're calling the method on.

Take the bark method for a quick test drive

Enough talking about constructors, let's add the code above to an HTML page, and then add the code below to test it:

```
var fido = new Dog("Fido", "Mixed", 38);
var fluffy = new Dog("Fluffy", "Poodle", 30);
var spot = new Dog("Spot", "Chihuahua", 10);
var dogs = [fido, fluffy, spot];

for (var i = 0; i < dogs.length; i++) {
    dogs[i].bark();
}
```



Make sure your dog objects bark like they're supposed to.

We've got a constructor to create coffee drinks, but it's missing its methods.

We need a method, getSize, that returns a string depending on the number of ounces of coffee:

- 8oz is a small
- 12oz is a medium
- 16oz is a large

We also need a method, toString, that returns a string that represents your order, like "You've ordered a small House Blend coffee."

Write your code below, and then test it in the browser. Try creating a few different sizes of coffee. Check your answer before you go on.

```
function Coffee(roast, ounces) {
    this.roast = roast;
    this.ounces = ounces;



}

var houseBlend = new Coffee("House Blend", 12);
console.log(houseBlend.toString());

var darkRoast = new Coffee("Dark Roast", 16);
console.log(darkRoast.toString());
```

Write the two methods for this constructor here.

Here's our output; yours should look similar.

JavaScript console

```
You've ordered a medium House Blend coffee.
You've ordered a large Dark Roast coffee.
```

there are no Dumb Questions

Q: Why do constructor names start with a capital letter?

A: This is a convention that JavaScript developers use so they can easily identify which functions are constructors, and which functions are just regular old functions. Why? Because with constructor functions, you need to use the new operator. In general, using a capital letter for constructors makes them easier to pick out when you're reading code.

Q: So, other than setting up the properties of the `this` object, a constructor's just like a regular function?

A: If you mean computationally, yes. You can do anything in a constructor you can do in a regular function, like declare and use variables, use for loops, call other functions, and so on. The only thing you don't want to do is return a value (other than **this**) from a constructor because that will cause the constructor to not return the object it's supposed to be constructing.

Q: Do the parameter names of a constructor function have to match the property names?

A: No. You can use whatever names you want for the parameters. The parameters are just used to hold values that we want to assign to the object's properties to customize the object. What matters is the name of the properties you use for the object. That said, we often do use the same names for clarity, so we know which properties we're assigning by looking at the constructor function definition.

Q: Is an object created by a constructor just like an object created with a literal?

A: Yes, until you get into more advanced object design, which we'll do in the next chapter.

Q: Why do we need `new` to create objects? Couldn't we create an object in a regular function and return it (kind of like we did with makeCar in chapter 5)?

A: Yes, you could create objects that way, but like we said in the previous answer, there are some extra things that happen when you use `new`. We'll get more into these issues later in this chapter, and again in Chapter 13.

Q: I'm still a bit confused by `this` in the constructor. We're using `this` to assign properties to the object, and we're also using `this` in the methods of the object. Are these the same thing?

A: When you call a constructor (to create an object) the value of **this** is set to the new object that's being created so all the code that is evaluated in the constructor applies to that new object.

Later, when you call a method on an object, **this** is set to the object whose method you called. So the **this** in your methods will always refer to the object whose method was called.

Q: Is it better to create objects with a constructor than with object literals?

A: Both are useful. A constructor is useful when you want to create lots of objects with the same property names and methods. Using them is convenient, reuses code, and provides consistency across your objects.

But sometimes we just need a quick object, perhaps a one-time-use only object, and literals are concise and expressive to use for this.

So it really depends what your needs are. Both are great ways to create an object.

We'll see a good example of this a bit later.

DANGER ZONE

There's one aspect of constructors you need to be very careful about: don't forget to use the **new** keyword. It's easy to do because a constructor is, after all, a function, and you can call it without **new**. *But if you forget **new** on a constructor it can lead to buggy code that is hard to troubleshoot.* Let's take a look at what can happen when you forget the **new** keyword...

```
function Album(title, artist, year) {
    this.title = title;
    this.artist = artist;
    this.year = year;
    this.play = function() {
        // code here
    };
}
var darkside = Album("Dark Side of the Cheese","Pink Mouse", 1971);
darkside.play();
```

This looks like a well-constructed constructor.

But maybe that's okay because Album is a function.

Oops we forgot to use new!

Let's try to call the play method anyway. Oh, this isn't good...

```
Uncaught TypeError: Cannot call method 'play' of undefined
```

SAFETY CHECKLIST

Okay, let's read the checklist to see why this might have happened:

- ❏ Remember that **new** first creates a new object before assigning it to **this** (and then calling your constructor function). If you don't use **new**, a new object will never be created.
- ❏ That means any references to **this** in your constructor won't refer to a new album object, but rather, will refer to the global object of your application.
- ❏ If you don't use **new** there's no object to return from the constructor, which means there is no object assigned to the darkside variable, so darkside is undefined. That's why when we try to call the play method, we get an error saying the object we're trying to call it on is undefined.

The global object is the top-level object, which is where global variables get stored. In browsers, this object is the window object.

If you're using a constructor to create objects and those objects keep coming up undefined when you reference them, double check your code and make sure you're using a **new** operator with your constructor.

And if you're holding an open test tube with liquid in it, tilted, above an expensive laptop, you should probably double-check that too!

The Constructor Exposed

This week's interview:
Getting to know new

Head First: `new`, where have you been hiding? How did we get to Chapter 12 before seeing you?

new: There are still a lot of scripts out there that don't use me, or use me without understanding me.

Head First: Why is that?

new: Because many scripters just use object literals or copy & paste code that uses me, without understanding how I work.

Head First: That's a good point… object literals are convenient, and I myself am not quite clear on when or how to use you just yet.

new: Well it's true, I am kind of an advanced feature. After all, to know how to use me, you first have to know how objects work, and how functions work, and how `this` works... it's a lot to wrap your head around before you even learn about me at all!

Head First: Can you give us the elevator pitch about yourself? Now that our readers know about objects, functions, and `this`, it would be great for them to get motivated for learning about you.

new: Let me think for a second… Okay here you go: I'm the operator that operates on constructor functions to create new objects.

Head First: Umm, I hate to break it to you but that isn't the best elevator pitch.

new: Gimme a break, I'm an operator, not a PR lackey.

Head First: Well, you do raise several questions with that pitch. First of all, you're an operator?

new: Yup! I'm an operator. Put me in front of a function call and I change everything. An operator operates on its operands. In my case, I have only one operand and that operand is a function call.

Head First: Right, so explain exactly how you operate.

new: Well, first, I make a new object. Everyone thinks that the constructor function is what does it, but it's actually me. It's a thankless job.

Head First: Go on…

new: Okay, so then I call the constructor function and make sure that the new object I've created is referenced by the `this` keyword in the body of the function.

Head First: Why do you do that?

new: So that the statements in the body of the function have a way to refer to the object. After all, the whole point of a constructor function is to extend that object using new properties and methods. If you're using the constructor to create objects like dogs and cars, you're going to want those objects to have some properties, right?

Head First: Right. And then?

new: Then I make sure that the new object that was created is returned from the constructor. It's a nice convenience so that developers don't have to remember to return it themselves.

Head First: It does sound very convenient. Now why would anyone use an object literal after learning you?

new: Oh, object literal and I go way back. He's a great guy, and I'd use him in a second if I had to create a quick object. But, you want me when you've got to create a lot of similar objects, when you want to make sure your objects are taking advantage of code reuse, when you want to ensure some consistency, and after you've learned a little more, to support some even more advanced uses.

Head First: More advanced? Oh do tell!

new: Now now, let's keep these readers focused. We'll talk more in the next chapter.

Head First: I think I need to re-read this interview first! Until then…

It's Production Time!

You've learned your object construction skills just in time because we've just received a big order for cars and we can't be creating them all by hand. We need to use a constructor so we can get the job done on time. We're going to do that by taking the car object literals we've used so far in the book, and using them as a guide for creating a constructor to make cars.

Check out the various kinds of cars we need to build below. Notice we've already taken the liberty of making their properties and methods uniform, so they all match across each car. For now, we won't worry about special options, or toy cars and rocket cars (we'll come back to that later). Go ahead and take a look, and then let's build a constructor that can create car objects for any kind of car that has these property names and methods:

```
var chevy = {
    make: "Chevy",
    model: "Bel Air",
    year: 1957,
    color: "red",
    passengers: 2,
    convertible: false,
    mileage: 1021,
    started: false,

    start: function() {
      this.started = true;
    },

    stop: function() {
      this.started = false;
    },

    drive: function() {
      if (this.started) {
        console.log(this.make + " " +
              this.model + " goes zoom zoom!");
      } else {
        console.log("Start the engine first.");
      }
    }
};
```

```
var cadi = {
    make: "GM",
    model: "Cadillac",
    year: 1955,
    color: "tan",
    passengers: 5,
    convertible: false,
    mileage: 12892,
    ...: false,
    ...function() {...},
    ...unction() {...},
    ...function() {...}
```

```
var fiat = {
    make: "Fiat",
    model: "500",
    year: 1957,
    color: "Medium Blue",
    passengers: 2,
    convertible: false,
    mileage: 88000,
    started: false,
    start: function() {...},
    stop: function() {
    drive: function()
};
```

```
var taxi = {
    make: "Webville Motors",
    model: "Taxi",
    year: 1955,
    color: "yellow",
    passengers: 4,
    convertible: false,
    mileage: 281341,
    started: false,
    start: function() {...},
    stop: function() {...},
    drive: function() {...}
};
```

Exercise

Use everything you've learned to create a Car constructor. We suggest the following order:

1. Start by providing the function keyword (actually we did that for you) followed by the constructor name. Next supply the parameters; you'll need one for each property that you want to supply an initial value for.

2. Next, assign each property in the object its initial value (make sure you use `this` along with the property name).

3. Finally, add in the three car methods: start, drive and stop.

```
function ________(_____________________________________________) {

}
```

All your work goes here.

Make sure you check all your work with the answer at the end of the chapter before proceeding!

Let's test drive some new cars

Now that we have a way to mass-produce car objects, let's make some, and put them through their paces. Start by putting the Car constructor in an HTML page, then add some test code.

Note: you won't be able to do this unless you did the exercise on the previous page!

Here's the code we used; feel free to alter and extend it:

First we're using the constructor to create all the cars from Chapter 5.

```
var chevy = new Car("Chevy", "Bel Air", 1957, "red", 2, false, 1021);
var cadi = new Car("GM", "Cadillac", 1955, "tan", 5, false, 12892);
var taxi = new Car("Webville Motors", "Taxi", 1955, "yellow", 4, false, 281341);
var fiat = new Car("Fiat", "500", 1957, "Medium Blue", 2, false, 88000);
```

But why stop there?

```
var testCar = new Car("Webville Motors", "Test Car", 2014, "marine", 2, true, 21);
```

Let's create the book's test drive car! →

Feel free to add your own favorite or fictional car too.

Are you starting to see how easy creating new objects can be with constructors? Now let's take these cars for a test drive:

```
var cars = [chevy, cadi, taxi, fiat, testCar];

for(var i = 0; i < cars.length; i++) {
    cars[i].start();
    cars[i].drive();
    cars[i].drive();
    cars[i].stop();
}
```

Here's the output we got. Did you add your own car to the mix? Try changing what the cars do (like driving before the car is started). Or, maybe you can make the number of times we call the drive method random?

JavaScript console

```
Chevy Bel Air goes zoom zoom!
Chevy Bel Air goes zoom zoom!
GM Cadillac goes zoom zoom!
GM Cadillac goes zoom zoom!
Webville Motors Taxi goes zoom zoom!
Webville Motors Taxi goes zoom zoom!
Fiat 500 goes zoom zoom!
Fiat 500 goes zoom zoom!
Webville Motors Test Car goes zoom zoom!
Webville Motors Test Car goes zoom zoom!
```

Don't count out object literals just yet

We've had some discussion of object constructors versus object literals, and mentioned that object literals are still quite useful, but you really haven't seen a good example of that. Well, let's do a little reworking of the Car constructor code, so you can see where using some object literals actually cleans up the code and makes it more readable and maintainable.

Let's look at the Car constructor again and see how we might be able to clean it up a bit.

Notice we're using a lot of parameters here. We count seven.

The more we add (and we always end up adding more as the requirements for objects grow), the harder this is to read.

```
function Car(make, model, year, color, passengers, convertible, mileage) {
    this.make = make;
    this.model = model;
    this.year = year;
    this.color = color;
    this.passengers = passengers;
    this.convertible = convertible;
    this.mileage = mileage;
    this.started = false;

    this.start = function() {
        this.started = true;
    };
    //rest of the methods here
}
```

And when we write code that calls this constructor we have to make sure we get the arguments all in exactly the right order.

So the problem we're highlighting here is that we have a heck of a lot of parameters in the Car constructor, making it difficult to read and maintain. It's also difficult to write code to call this constructor. While that might seem like a minor inconvenience, it actually causes more bugs than you might think, and not only that, they're often nasty bugs that are hard to diagnose at first.

They're hard to diagnose because if you switch two variables, the code is still syntactically correct, but it doesn't function correctly because you've switched two values.

Or if you leave out a value, all kinds of craziness can ensue!

However, there is a common technique that we can use when passing all these arguments that can be used for any function, whether or not it's a constructor. The technique works like this: take all your arguments, throw them in an object literal, and then pass that literal to your function—that way you're passing all your values in one container (the literal object) and you don't have worry about matching the order of your arguments and parameters.

Let's rewrite the code to call the Car constructor, and then do a slight rework of the constructor code to see how this works.

Rewiring the arguments as an object literal

Let's take the call to the Car constructor and rework its arguments into an object literal:

All you need to do is take each argument and place it in an object literal with an appropriate property name. We use the same property names used in the constructor.

```
var cadi = new Car("GM", "Cadillac", 1955, "tan", 5, false, 12892);
```

```
var cadiParams = {make: "GM",
                  model: "Cadillac",
                  year: 1955,
                  color: "tan",
                  passengers: 5,
                  convertible: false,
                  mileage: 12892};
```

We've kept the same order, but there is no reason you'd have to.

And then we can rewrite the call to the Car constructor like this:

```
var cadiParams = {make: "GM",
                  model: "Cadillac",
                  year: 1955,
                  color: "tan",
                  passengers: 5,
                  convertible: false,
                  mileage: 12892};

var cadi = new Car(cadiParams);
```

Wow, talk about a makeover. Not only is this much cleaner, it's a lot more readable, at least in our humble opinion.

Now we're passing a single argument to the Car constructor.

But we're not done yet because the constructor itself is still expecting seven arguments, not one object. Let's rework the constructor code, and then we'll give this a test.

Reworking the Car constructor

Now you need to remove all the individual parameters in the Car constructor and replace them with properties from the object that we're passing in. We'll call that parameter `params`. You also need to rework the code a bit to use this object. Here's how:

```
var cadiParams = {make: "GM",
                  model: "Cadillac",
                  year: 1955,
                  color: "tan",
                  passengers: 5,
                  convertible: false,
                  mileage: 12892};

var cadi = new Car(cadiParams);

function Car(params) {
    this.make = params.make;
    this.model = params.model;
    this.year = params.year;
    this.color = params.color;
    this.passengers = params.passengers;
    this.convertible = params.convertible;
    this.mileage = params.mileage;
    this.started = false;

    this.start = function() {
        this.started = true;
    };
    this.stop = function() {
        this.started = false;
    };
    this.drive = function() {
        if (this.started) {
            alert("Zoom zoom!");
        } else {
            alert("You need to start the engine first.");
        }
    };
}
```

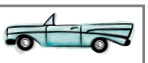
No changes here, we've just reproduced the object literal and the call to the Car constructor from the previous page.

First things first. We'll replace the seven parameters of the Car constructor with one parameter, for the object we're passing in.

Then for each reference to a parameter, we substitute the corresponding property from the object passed into the function.

In our methods we never use a parameter directly. It wouldn't make sense to because we always want to use the object's properties (which we do using the this variable). So, no changes are needed to this code at all.

Test drive



Update the `cadi` and all your other cars, and test your code.

```
cadi.start();
cadi.drive();
cadi.drive();
cadi.stop();
```

Exercise

Copy the Car and Dog constructors into one file, and then add the code below along with it. Give this a run and capture the output.

You'll find the Dog constructor on page 530.

```
var limoParams = {make: "Webville Motors",
                  model: "limo",
                  year: 1983,
                  color: "black",
                  passengers: 12,
                  convertible: true,
                  mileage: 21120};

var limo = new Car(limoParams);
var limoDog = new Dog("Rhapsody In Blue", "Poodle", 40);

console.log(limo.make + " " + limo.model + " is a " + typeof limo);
console.log(limoDog.name + " is a " + typeof limoDog);
```

Put the output here.

Say someone handed you an object and you wanted to know what type of object it was (is it a Car? a Dog? Superman?), or you wanted to see if it was the same type as another object. Would the typeof operator be helpful?

there are no Dumb Questions

Q: Remind me what typeof does again?

A: The typeof operator returns the type of its operand. If you pass it a string you'll get back "string", if you pass it an object you'll get back "object" and so on. You can pass it any type: a number, a string, a boolean, or a more complex type like an object or function. But typeof can't be more specific and tell you the object is a dog or a car.

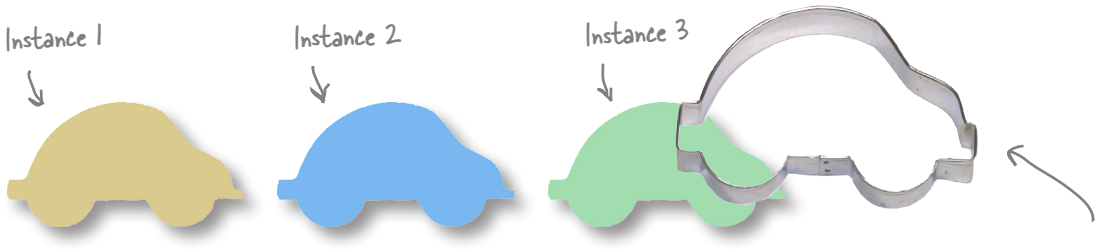
Q: So if typeof can't tell me that my object is a dog or car, how do I determine what is what?

A: Many other object-oriented languages, like Java or C++, have a strong notion of object typing. In those languages you can examine an object and determine exactly what type of object it is. But, JavaScript treats objects and their types in a looser, more dynamic way. Because of this, many developers have jumped to the conclusion that JavaScript has a less powerful object system, but the truth is, its object system is actually more general and flexible. Because JavaScript's type system is more dynamic, it's a little more difficult to determine if an object is a dog or a car, and it depends on what you think a dog is or a car is. However, we have another operator that can give us a little more information... so continue reading.

Understanding Object Instances

You can't look at a JavaScript object and determine that it is an object of a specific type, like a dog or a car. In JavaScript, objects are dynamic structures, and the type of all objects is just "object," no matter what properties and methods it has. But we can get some information about an object if we know the *constructor* that created the object.

Remember that each time you call a constructor using the `new` operator, you are creating a new instance of an object. And, if you used, say, the Car constructor to do that, then we say, informally, that the object is a car. More formally, we say that object is an *instance of* a Car.



As you know, each instance can have its own unique set of property values, but we think of all the objects created from the Car constructor as instances of Car.

You can think of these cars as being the same kind of object because they all were created by the same constructor.

Now saying an object is an instance of some constructor is more than just talk. We can actually write code to inspect the constructor that made an object with the `instanceof` operator. Let's look at some code:

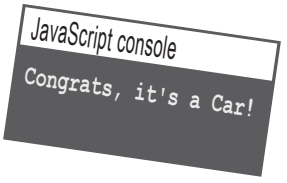
```
var cadiParams = {make: "GM", model: "Cadillac", year: 1955, color: "tan",
                  passengers: 5, convertible: false, mileage: 12892};

var cadi = new Car(cadiParams);

if (cadi instanceof Car) {
    console.log("Congrats, it's a Car!");
};
```

The instanceof operator returns true if the object was created by the specified constructor.

In this case we're saying "Is the cadi object an instance that was created by the Car constructor?"

As it turns out, one of the things the `new` operator does behind the scenes when the object is created is to store information that allows it to determine, at any time, the constructor that created the object. And `instanceof` uses that to determine if an object is an instance of a certain constructor.

It's a bit more complicated than we're describing here, but we'll talk about that in the next chapter.



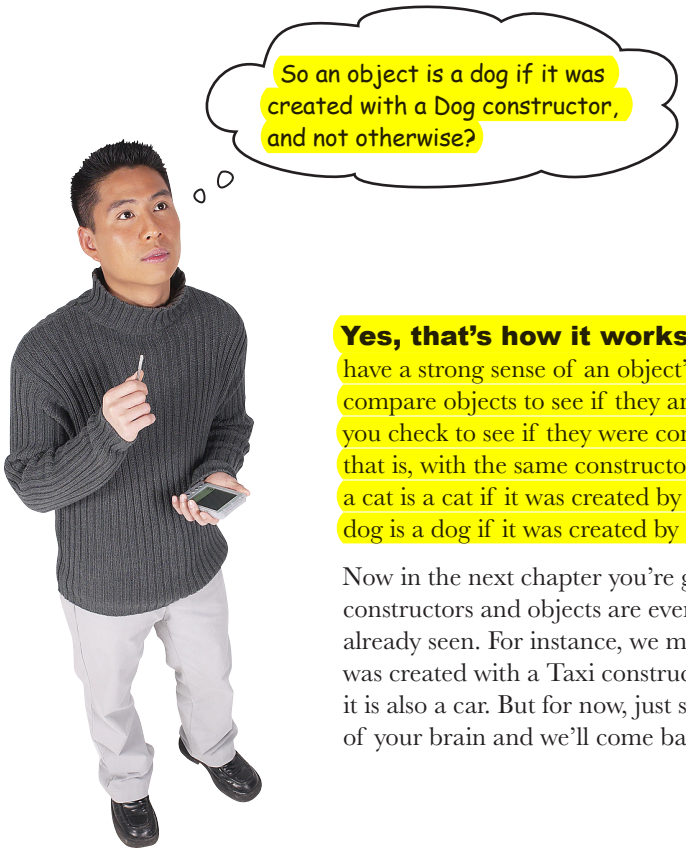
We need a function named dogCatcher that returns true if the object passed to it is a dog, and false otherwise. Write that function and test it with the rest of the code below. Don't forget to check your answer at the end of the chapter before you go on!

```
function dogCatcher(obj) {



}
```

Add your code here to implement the dogCatcher function.

And here's your test code.

```
function Cat(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
}
var meow = new Cat("Meow", "Siamese", 10);
var whiskers = new Cat("Whiskers", "Mixed", 12);

var fido = {name: "Fido", breed: "Mixed", weight: 38};

function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.bark = function() {
        if (this.weight > 25) {
            alert(this.name + " says Woof!");
        } else {
            alert(this.name + " says Yip!");
        }
    };
}
var fluffy = new Dog("Fluffy", "Poodle", 30);
var spot = new Dog("Spot", "Chihuahua", 10);
var dogs = [meow, whiskers, fido, fluffy, spot];

for (var i = 0; i < dogs.length; i++) {
    if (dogCatcher(dogs[i])) {
        console.log(dogs[i].name + " is a dog!");
    }
}
```



Yes, that's how it works. JavaScript doesn't have a strong sense of an object's type, so if you need to compare objects to see if they are both cats or both dogs, you check to see if they were constructed the same way—that is, with the same constructor function. As we've said, a cat is a cat if it was created by the Cat constructor, and a dog is a dog if it was created by the Dog constructor.

Now in the next chapter you're going to see JavaScript constructors and objects are even more flexible than we've already seen. For instance, we might have an object that was created with a Taxi constructor, and yet we know that it is also a car. But for now, just stash that idea in the back of your brain and we'll come back to it later.

Even constructed objects can have their own independent properties

We've talked a lot about how to use constructors to create consistent objects—objects that have the same set of properties and the same methods. But what we haven't mentioned is that using constructors still doesn't prevent us from changing an object into something else later, because after an object has been created by a constructor, it can be altered.

What exactly are we talking about? Remember when we introduced object literals? We looked at how we could add and delete properties after the object was created. You can do the same with objects created from constructors:

Here's our dog Fido, created with the Dog constructor.

```
var fido = new Dog("Fido", "Mixed", 38);
fido.owner = "Bob";
delete fido.weight;
```

We can add a new property just by assigning it a value in our object.

Or we can get rid of a property by using the delete operator.

You can even add new methods if you like:

To add a method just assign the method to a new property name in the object.

```
fido.trust = function(person) {
                return (person === "Bob");
             };
```

Anonymous function alert! See, they're everywhere!

Notice that here we're changing only the fido object. If we add a method to fido, only fido has that method. No other dogs have it:

```
var notBite = fido.trust("Bob");
```

This code works because trust is defined in the fido object. So notBite is true.

```
var spot = new Dog("Spot", "Chihuahua", 10);
notBite = spot.trust("Bob");
```

This code doesn't work because spot doesn't have a method trust, resulting in: "TypeError: Object #<Dog> has no method 'trust'"

Yes, a car is still a car, even if you change it later.
And what we mean by that is if you check to see if your object is still an instance of Car, it will be. For instance, if we create a car object:

```
var cadiParams = {make: "GM", model: "Cadillac",
                  year: 1955, color: "tan",
                  passengers: 5, convertible: false,
                  mileage: 12892};
var cadi = new Car(cadiParams);
```

We can add a new property `chrome` and delete the property `convertible`:

```
cadi.chrome = true;
delete cadi.convertible;
```

and yet, the `cadi` is still a car:

```
cadi instanceof Car
```

Evaluates to true.

This is what we meant earlier when we said that JavaScript has a dynamic type system.

Now is it really a car in practical terms? What if we deleted every property in the object? Would it still be a car? The `instanceof` operator would tell us yes. But judging by our own terms, probably not.

Chances are, you won't often want to use a constructor to create an object and then later change it into something that's unrecognizable as an object created by that constructor. In general, you'll use constructors to create objects that are fairly consistent. But if you need objects that are more flexible, well, JavaScript can handle that. It's your job as a code designer to decide how to use constructors and objects in a way that makes sense for you (and don't forget your coworkers).

Real World Constructors

JavaScript comes with a set of constructors for instantiating some handy objects—like objects that know how to deal with dates and times, objects that are great at finding patterns in text, and even objects that will give you a new perspective on arrays. Now that you know how constructors work, and also how to use the `new` keyword, you're in a great position to make use of these constructors, or more importantly the objects they create. Let's just take a quick dip into a couple, and then you'll be all ready to go out and explore them on your own.

Let's start with JavaScript's built-in date object. To get one we just use its constructor:

```
var now = new Date();
```

Creates a new date representing the current date and time.

Calling the Date constructor gives you back an instance of Date that represents the current local date and time. With a date object in hand, you can then use its methods to manipulate dates (and times) and also retrieve various properties of a date and time. Here are a few examples:

```
var dateString = now.toString();
```

Returns a string that represents the date, like "Thu Feb 06 2014 17:29:29 GMT-0800 (PST)".

```
var theYear = now.getFullYear();
```

Returns the year in the date.

```
var theDayOfWeek = now.getDay();
```

Returns a number for the day of the week represented by the date object, like 1 (for Monday).

You can easily create date objects representing any date and time by passing additional arguments to the Date constructor. For instance, say you need a date object representing "May 1, 1983", you can do that with:

```
var birthday = new Date("May 1, 1983");
```

You can pass a simple date string to the constructor like this.

And you can get even more specific by including a time:

```
var birthday = new Date("May 1, 1983 08:03 pm");
```

Now, we're including a time in the string too.

We are, of course, just giving you a flyby of the date object; you'll want to check out its full set of properties and methods in *JavaScript: The Definitive Guide*.

The Array object

Next up, another interesting built-in object: the array object. While we've been creating arrays using the square bracket notation [1, 2, 3], you can create arrays using a constructor too:

```
var emptyArray = new Array();
```

Creates an empty array with length zero.

Here, we're creating a new, empty array object. And at any time we can add items to it, like this:

```
emptyArray[0] = 99;
```

This should look familiar. This is the same way we've always added items to an array.

We can also create array objects that have a specific size. Say we want an array with three items:

```
var oddNumbers = new Array(3);
oddNumbers[0] = 1;
oddNumbers[1] = 3;
oddNumbers[2] = 5;
```

We create an array of length three, and fill it in with values after we create it.

Here we've created an array of length three. Initially the three items in `oddNumbers` are undefined, but we then set each item in the array to a value. You could easily add more items to the array if you wanted.

None of this should be shockingly different than what you're used to. Where the array object gets interesting is in its set of methods. You already know about array's `sort` method, and here are a few other interesting ones:

```
oddNumbers.reverse();
```

This reverses all the values in the array (so we have 5, 3, 1 in oddNumbers now). Notice, the method changes the original array.

```
var aString = oddNumbers.join(" - ");
```

The join method creates a string from the values in oddNumbers placing a " - " between the values, and returns that string. So this returns the string "5 - 3 - 1".

```
var areAllOdd = oddNumbers.every(function(x) {
    return ((x % 2) !== 0);
});
```

The every method takes a function and tests each value of the array to see if the function returns true or false when called on that value. If the function returns true for all the array items, then the result of the every method is true.

Again, that's just the tip of the iceberg, so take a look at *JavaScript: The Definitive Guide* to fully explore the array object. You've got all the knowledge you need to take it on.

Good catch. The bracket notation, [ ], that you've been using to create arrays is actually just a shorthand for using the Array constructor directly. Check out these two equivalent ways of creating empty arrays:

```
var items = new Array();
var items = [];
```

These do the same thing. The bracket notation is supported in the JavaScript language to make your life easier when creating arrays.

Likewise, if you write code like this:

```
var items = ["a", "b", "c"];
```

We call this array literal syntax.

That's just a shorthand for using the constructor in another way:

```
var items = new Array("a", "b", "c");
```

If you pass more than one argument, this creates an array holding the values you pass it.

And, the objects created from the literal notation or by using the constructor directly are the same, so you can use methods on either one.

You might be asking why you'd ever use the constructor rather than the literal notation. The constructor comes in handy when you need to create an array of a specific size you determine at runtime, and then add items to it later, like this:

```
var n = getNumberOfWidgetsFromDatabase();
var widgets = new Array(n);
for(var i=0; i < n; i++) {
    widgets[i] = getDatabaseRecord(i);
}
```

This code presumably uses big arrays that we won't know the size of until runtime.

So, for creating a quick array, using the array literal syntax to create your array objects works wonderfully, but using the Array constructor might make sense when you're creating the array programmatically. You can use either or both as much as you want.

Even more fun with built-in objects

Date and array aren't the only built-in objects in JavaScript. There are lots of other objects that come with the language you might find handy at times. Here's a short list (there are more, so search online for "JavaScript's standard built-in objects" if you're curious!).

Object By using the Object constructor you can create objects. Like arrays, the object literal notation { } is equivalent to using new Object(). More on this later.

Math This object has properties and methods for doing math stuff. Like Math.PI and Math.random().

RegExp Use this constructor to create regular expression objects, which allow you to search for patterns, even complex ones, in text.

Error This constructor creates standard error objects that are handy when catching errors in your code.

there are no Dumb Questions

Q: I'm confused by how the Date and Array constructors work: they seem to support zero or more arguments. Like with Date, if I don't provide an argument, then I get today's date, but I can also pass arguments to get other dates. How does that work?

A: Right, good catch. It's possible to write functions that do different things based on the number of arguments. So if the Array constructor has zero arguments, the constructor knows it is creating an empty array; if it has one argument it knows that's the size of the array, and if it has more, then those arguments are all initial values.

Q: Can we do that with our constructors?

A: Of course. This is something we haven't covered, but every function gets passed an arguments object that contains all the arguments passed to the function. You can use this to determine what was passed and act appropriately (check the appendix for more on the arguments object). There are other techniques based on checking to see which of your parameters is set to undefined.

Q: We used Math earlier in the book. Why don't I have to say "new Math" to instantiate a math object before I use it?

A: Great question. Actually, Math is not a constructor, or even a function. It's an object. As you know, Math is a built-in object that you can use to do things like get the value of pi (with `Math.PI`) or generate a random number (with `Math.random`). Think of Math as just like an object literal that has a bunch of useful properties and methods in it, built-in for you to use whenever you write JavaScript code. It just happens to have a capital first letter to let you know that it's built-in to JavaScript.

Q: I know how to check if an object is an instance of a constructor name, but how do I write the code to ask if two objects have the same constructor?

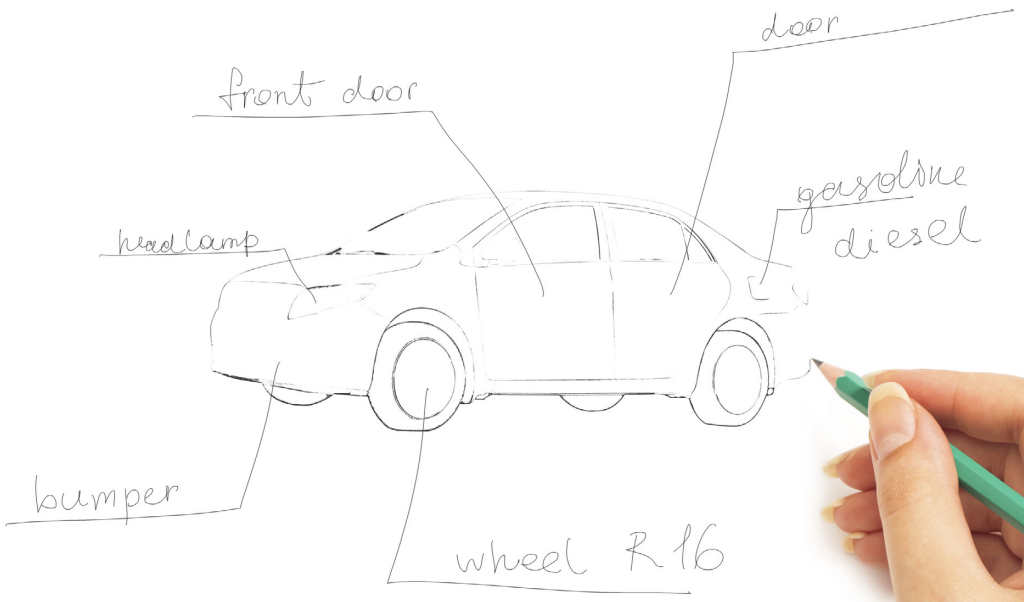
A: You can check to see if two objects have the same constructor like this:

```
((fido instanceof Dog) &&
          (spot instanceof Dog))
```

If this expression results in true, then fido and spot were indeed created by the same constructor.

Q: If I create an object with an object literal, what is it an instance of? Or is it not an instance of anything?

A: An object literal is an instance of Object. Think of Object as the constructor for the most generic kind of object in JavaScript. You'll learn much more about how Object figures into JavaScript's object system in the next chapter.



Webville Motors is revolutionizing car production by creating all their cars from a prototype car. The prototype gives you all the basics you need: a way to start, drive and stop it along with a couple properties like the make and year it was manufactured—but the rest is up to you. Want it to be red or blue? No problem, just customize it. Need for it to have a fancy stereo? No problem, go crazy, add it.

So this is your opportunity to design your perfect car. Create a CarPrototype object below, and make the car of your dreams. Check out our design at the end of the chapter before moving on.

Draw your car here.

```
function CarPrototype() {
    this.make = "Webville Motors";
    this.year = 2013;
    this.start = function() {...};
    this.stop = function() {...};
    this.drive = function() {...};
}
```

And customize the prototype here.

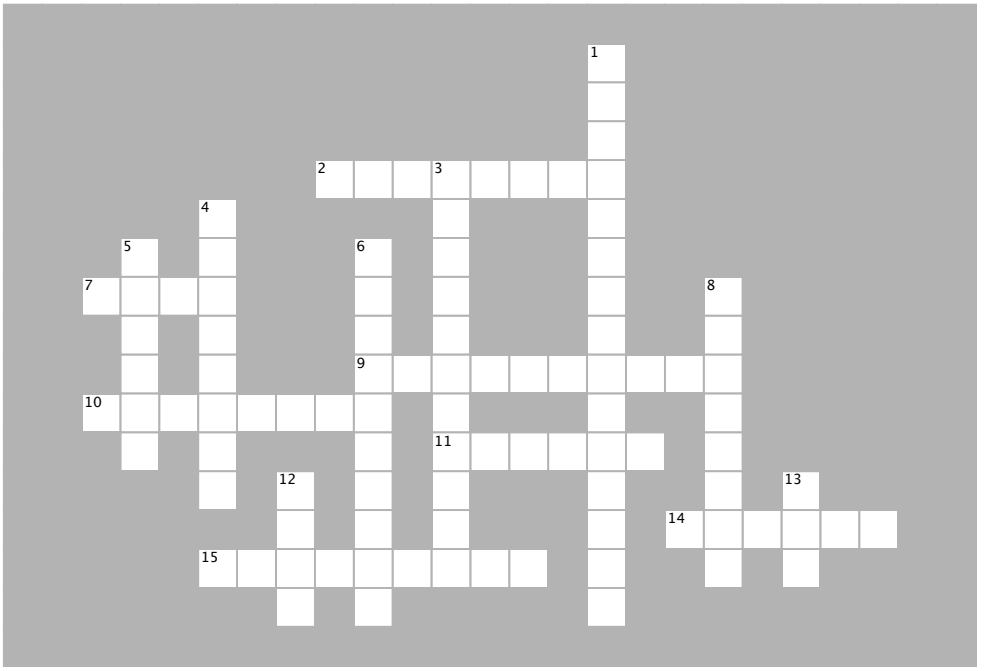
Oh, and where are we going with this? You'll find out in the next chapter! By the way, you're done with this chapter... Oh, but there's still the bullet points and the crossword puzzle to do!

BULLET POINTS

- An **object literal** works well when you need to create a small number of objects.
- A **constructor** works well when you need to create many similar objects.
- Constructors are functions that are meant to be used with the **new** operator. We capitalize the names of constructors by convention.
- Using a constructor we can create objects that are consistent, having the same property names and methods.
- Use the **new** operator with a constructor function call to create an object.
- When you use **new** with a constructor function call, it creates a new, empty object, which is assigned to **this** within the body of the constructor.
- Use **this** in a constructor function to access the object being constructed and add properties to the object.
- A new object is returned automatically by the constructor function.
- If you forget to use **new** with a constructor, no object is created. This will cause errors in your code that can be difficult to debug.
- To customize objects, we pass arguments to a constructor, and use those values to initialize the properties of the object being created.
- If a constructor has a lot of parameters, consider consolidating them into one object parameter.
- To know if an object was created by a specific constructor, use the **instanceof** operator.
- You can modify an object that was created by a constructor just like you can modify an object literal.
- JavaScript comes with a number of constructors you can use to create useful objects like date objects, regular expressions and arrays.

JavaScript cross

Construct some new connections in your brain with this crossword puzzle.



ACROSS

2. A constructor is a _____.

7. If you want to save my birthday in a variable, you'll need a _____ constructor.

9. You can use an object literal to pass arguments to a constructor when the constructor has lots of these.

10. When you create an object from a constructor, we say it is an _____ of the constructor.

11. A constructor is a bit like a _____ cutter.

14. The constructor function returns the newly constructed _____.

15. If you forget to use new with a constructor, you might see a _____.

DOWN

1. Constructor syntax is a bit _____.

3. You can add a property to an object created by a _____ whenever you want.

4. new is an _____, not a PR lackey.

5. The Webville Motors test car comes in this color.

6. Using a constructor, we can make our cars so they have all the same _____.

8. Never hold a _____ over your laptop.

12. The limo and the limoDog are the same _____.

13. To create an object with a constructor, you use the ____ operator.

Sharpen your pencil Solution

We need your help. We've been using object literals to create ducks. Given what you learned above, can you write a constructor to create ducks for us? You'll find one of our object literals below to base your constructor on. Here's our solution.

```
var duck = {
    type: "redheaded",
    canFly: true
}
```

Here's an example duck object literal.

Write a constructor for creating ducks.

```
function Duck(type, canFly) {
    this.type = type;
    this.canFly = canFly;
}
```

P.S. We know you haven't fully figured out how this all works yet, so for now concentrate on the syntax.

Exercise Solution

```
function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
}
var fido = new Dog("Fido", "Mixed", 38);
var fluffy = new Dog("Fluffy", "Poodle", 30);
var spot = new Dog("Spot", "Chihuahua", 10);
var dogs = [fido, fluffy, spot];

for (var i = 0; i < dogs.length; i++) {
    var size = "small";
    if (dogs[i].weight > 10) {
        size = "large";
    }
    console.log("Dog: " + dogs[i].name
                + " is a " + size
                + " " + dogs[i].breed);
}
```

Get some quick hands on experience to help this all sink in. Go ahead and put this code in a page and give it a test drive. Write your output here.

JavaScript console

```
Dog: Fido is a large Mixed
Dog: Fluffy is a large Poodle
Dog: Spot is a small Chihuahua
```

BE the Browser Solution

Below, you'll find JavaScript code with some mistakes in it. Your job is to play like you're the browser and find the errors in the code. Here's our solution.

If widget is to be a constructor, it needs a capital letter for W. That won't cause an error, but it's a good convention to follow.

```
function widget(partNo, size) {
    var this.no = partNo;
    var this.breed = size;
}
```

We don't need "var" in front of this. We're not declaring new variables, we're adding properties to an object.

Also, by convention we usually name the parameters the same as the property names. So probably this.partNo and this.size would be better.

```
function FormFactor(material, widget) {
    this.material = material,
    this.widget = widget,
    return this;
}
```

We're using commas instead of semicolons. Remember, in the constructor we use normal statements rather than comma separated property name/value pairs.

We're returning this and we don't need to. The constructor will do it for us. This statement won't cause an error, but it's not necessary.

```
var widgetA = widget(100, "large");
var widgetB = new widget(101, "small");
var formFactorA = newFormFactor("plastic", widgetA);
var formFactorB = new ForumFactor("metal", widgetB);
```

Forgot new!

Needs a space between new and the constructor name.

Misspelled the name of the constructor.

Exercise Solution

We've got a constructor to create coffee drinks, but it's missing its methods.

We need a method, getSize, that returns a string depending on the number of ounces of coffee:

- 8oz is a small
- 12oz is a medium
- 16oz is a large

We also need a method, toString, that returns a string specifying your order.

Write your code below, and then test it in the browser. Try creating a few different sizes of coffee. Here's our solution.

```
function Coffee(roast, ounces) {
    this.roast = roast;
    this.ounces = ounces;
    this.getSize = function() {
        if (this.ounces === 8) {
            return "small";
        } else if (this.ounces === 12) {
            return "medium";
        } else if (this.ounces === 16) {
            return "large";
        }
    };
    this.toString = function() {
        return "You've ordered a " + this.getSize() + " "
               + this.roast + " coffee.";
    };
}

var houseBlend = new Coffee("House Blend", 12);
console.log(houseBlend.toString());

var darkRoast = new Coffee("Dark Roast", 16);
console.log(darkRoast.toString());
```

The getSize method looks at the ounces property of the object, and returns the corresponding size string.

Remember, this will be the object whose method we call. So if we call houseBlend.size, then this will be the houseBlend object.

The toString method just returns a string description of the object. It uses the getSize method to get the size of the coffee.

We create two coffee objects and call the toString method and display the resulting string.

JavaScript console

```
You've ordered a medium House Blend coffee.
You've ordered a large Dark Roast coffee.
```

Here's our output; yours should look similar.

Use everything you've learned to create a Car constructor. We suggest the following order:

1. Start by providing the function keyword (actually we did that for you) followed by the constructor name. Next supply the parameters; you'll need one for each property that you want to supply an initial value for.
2. Next, assign each property in the object its initial value (make sure you use `this` along with the property name).
3. Finally, add in the three car methods: start, drive and stop.

Here's our solution.

The constructor name is Car.

And seven parameters, one for each property we want to customize.

```
1 function Car(make, model, year, color, passengers, convertible, mileage) {

  2   this.make = make;
      this.model = model;
      this.year = year;
      this.color = color;
      this.passengers = passengers;
      this.convertible = convertible;
      this.mileage = mileage;
      this.started = false;

  3   this.start = function() {
          this.started = true;
      };
      this.stop = function() {
          this.started = false;
      };
      this.drive = function() {
          if (this.started) {
              alert("Zoom zoom!");
          } else {
              alert("You need to start the engine first.");
          }
      };
  }
```

Each property of the new car object that's customized with a parameter is set to the parameter name. Notice we're using the same name for the property and the parameter by convention.

The started property is just initialized to false.

The methods are exactly the same as before, but now they're assigned to properties in the object with slightly different syntax because we're in a constructor not an object literal.

Copy the Car and Dog constructors into one file, and then add the code below along with it. Give this a run and capture the output. Here's our result:

```
var limoParams = {make: "Webville Motors",
                  model: "limo",
                  year: 1983,
                  color: "black",
                  passengers: 12,
                  convertible: true,
                  mileage: 21120};

var limo = new Car(limoParams);
var limoDog = new Dog("Rhapsody In Blue", "Poodle", 40);

console.log(limo.make + " " + limo.model + " is a " + typeof limo);
console.log(limoDog.name + " is a " + typeof limoDog);
```

JavaScript console

```
Webville Motors limo is a object
Rhapsody In Blue is a object
```

What we got.

Exercise Solution

We need a function, dogCatcher, that returns true if the object passed to it is a Dog, and false otherwise. Write that function and test it with the rest of the code below. Here's our solution:

```
function dogCatcher(obj) {
    if (obj instanceof Dog) {
        return true;
    } else {
        return false;
    }
}
```

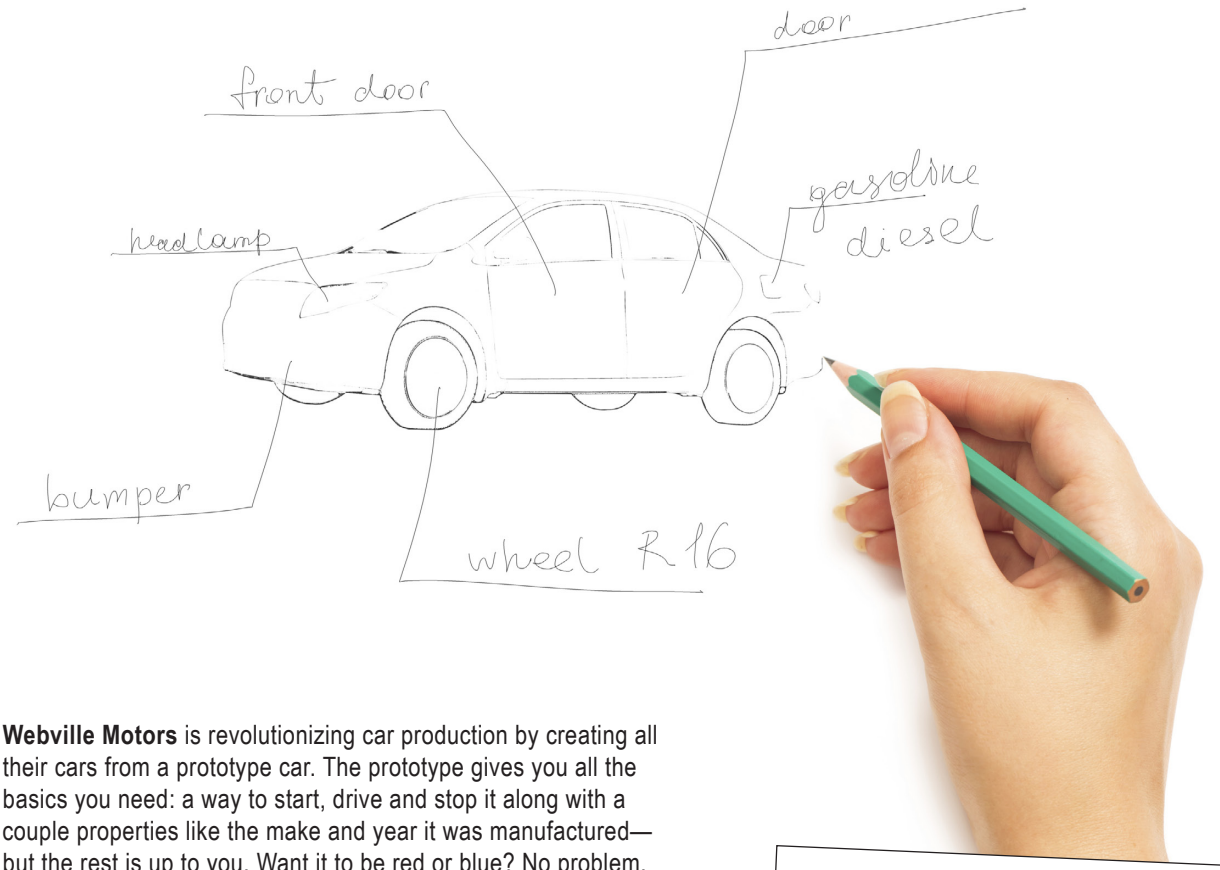
Or more succinctly:

```
function dogCatcher(obj) {
    return (obj instanceof Dog);
}
```

```
function Cat(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
}
var meow = new Cat("Meow", "Siamese", 10);
var whiskers = new Cat("Whiskers", "Mixed", 12);

var fido = {name: "Fido", breed: "Mixed", weight: 38};

function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.bark = function() {
        if (this.weight > 25) {
            alert(this.name + " says Woof!");
        } else {
            alert(this.name + " says Yip!");
        }
    };
}
var fluffy = new Dog("Fluffy", "Poodle", 30);
var spot = new Dog("Spot", "Chihuahua", 10);
var dogs = [meow, whiskers, fido, fluffy, spot];

for (var i = 0; i < dogs.length; i++) {
    if (dogCatcher(dogs[i]) {
        console.log(dogs[i].name + " is a dog!");
    }
}
```

JavaScript console

```
Fluffy is a dog!
Spot is a dog!
```



Webville Motors is revolutionizing car production by creating all their cars from a prototype car. The prototype gives you all the basics you need: a way to start, drive and stop it along with a couple properties like the make and year it was manufactured—but the rest is up to you. Want it to be red or blue? No problem, just customize it. Need for it to have a fancy stereo? No problem, go crazy, add it.

So this is your opportunity to design your perfect car. Check out our design below.

Draw your car here.

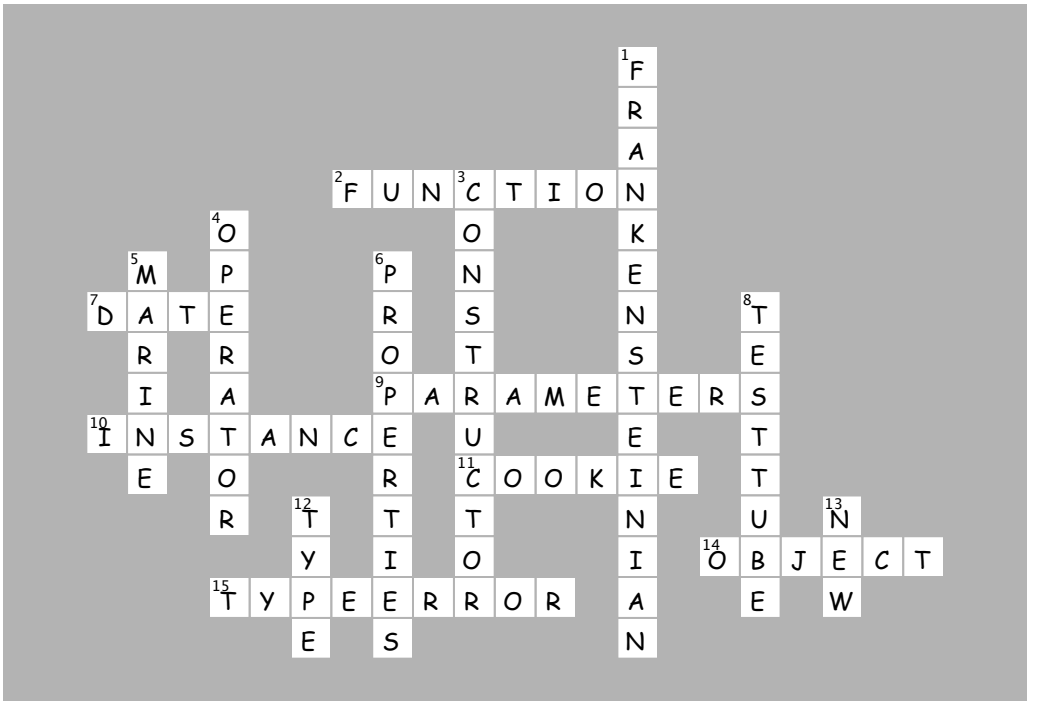
```
function CarPrototype() {
    this.make = "Webville Motors";
    this.year = 2013;
    this.start = function() {...};
    this.stop = function() {...};
    this.drive = function() {...};
}
```

```
var taxi = new CarPrototype();
taxi.model = "Delorean Remake";
taxi.color = "silver";
taxi.currentTime = new Date();
taxi.fluxCapacitor = {type: "Mr. Fusion"};
taxi.timeTravel = function(date) {...};
```

And customize the prototype here.

Oh, and where are we going with this? You'll find out in the next chapter! By the way, you're done with this chapter now.

JavaScript cross Solution



Extra strength objects

Learning how to create objects was just the beginning.

It's time to put some muscle on our objects. We need more ways to create **relationships** between objects and to **share code** among them. And, we need ways to extend and enhance existing objects. In other words, we need more tools. In this chapter, you're going to see that JavaScript has a very powerful **object model**, but one that is a bit different than the status quo object-oriented language. Rather than the typical class-based object-oriented system, JavaScript instead opts for a more powerful **prototype** model, where objects can inherit and extend the behavior of other objects. What is that good for? You'll see soon enough. Let's get started...

And if you haven't learned classical inheritance, you're lucky because you don't have to unlearn anything!

If you're used to Java, C++, or any language based on classical object-oriented programming let's have a quick chat.

And if you aren't... what, you got a date? Take a seat, and go along for the ride—you might just learn something as well.

We'll give it to you straight: JavaScript doesn't have a classical object-oriented model, where you create objects from classes. In fact, *JavaScript doesn't have classes at all*. In JavaScript, objects inherit behavior *from other objects*, which we call *prototypal inheritance*, or inheritance based on prototypes.

This may change in the future: the next version of JavaScript may add classes. So keep an eye out on wickedlysmart.com/hfjs for the latest on this.

JavaScript gets a lot of groans (and confused looks) from those trained in object-oriented programming, but know this: prototype-based languages are more general than classical object oriented ones. They're more flexible, efficient and expressive. So expressive that if you wanted to, you could use JavaScript to implement classical inheritance.

Left to the reader as an exercise.

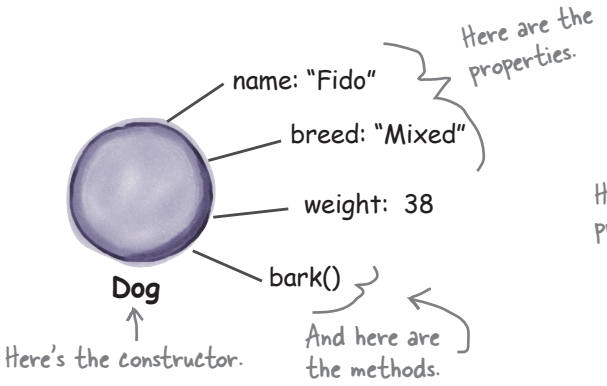
So, if you are trained in the art of classical object-oriented programming, sit back, relax, open your mind and be ready for something a little different. And if you have no idea what we're talking about when we say "classical object-oriented programming," that just means you're starting fresh, which is often a very good thing.

Hey, before we get started, we've got a better way to diagram our objects

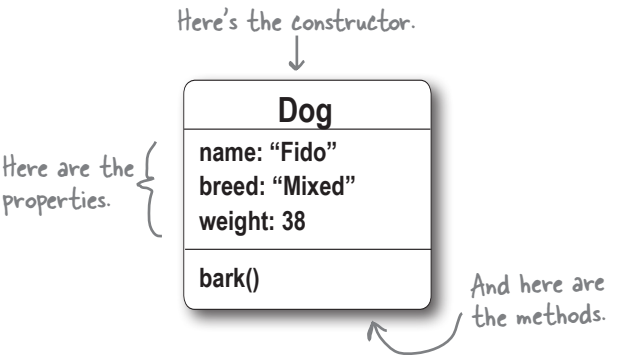
The object diagrams we've been using are cute and all that, but this is the *serious objects chapter*, so we're going to get more serious about our object diagrams. Actually, we really like the old ones, but the object diagrams in this chapter get complicated enough we just can't squeeze everything we need to into them.

So, without further ado, let us present the new format:

OLD SCHOOL

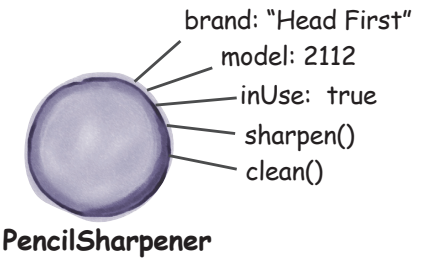


NEW AND IMPROVED

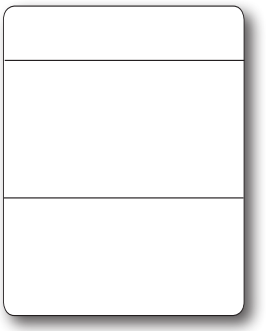


Sharpen your pencil

Do a little practice just to make sure you've got the new format down. Take the object below and redo it in the new and improved object diagram.



Fill in this object diagram.



Revisiting object constructors: we're reusing code, but are we being efficient?

Remember the Dog constructor we created in the last chapter? Let's take another quick look and review what we're getting out of using the constructor:

```
function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.bark = function() {
        if (this.weight > 25) {
            alert(this.name + " says Woof!");
        } else {
            alert(this.name + " says Yip!");
        }
    };
}
```

Every dog can have its own custom values and a consistent set of properties.

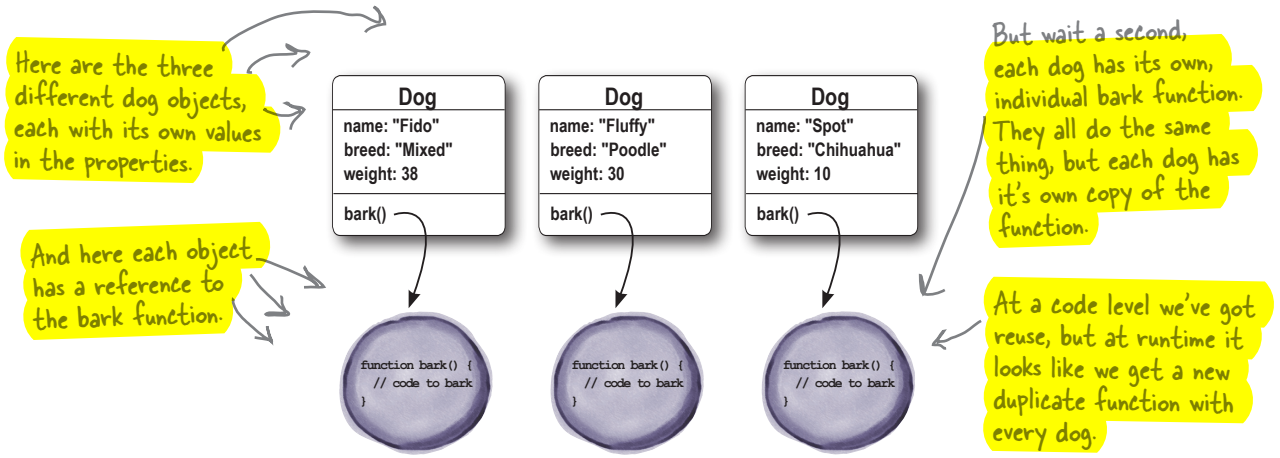
And every dog comes complete with a bark method.

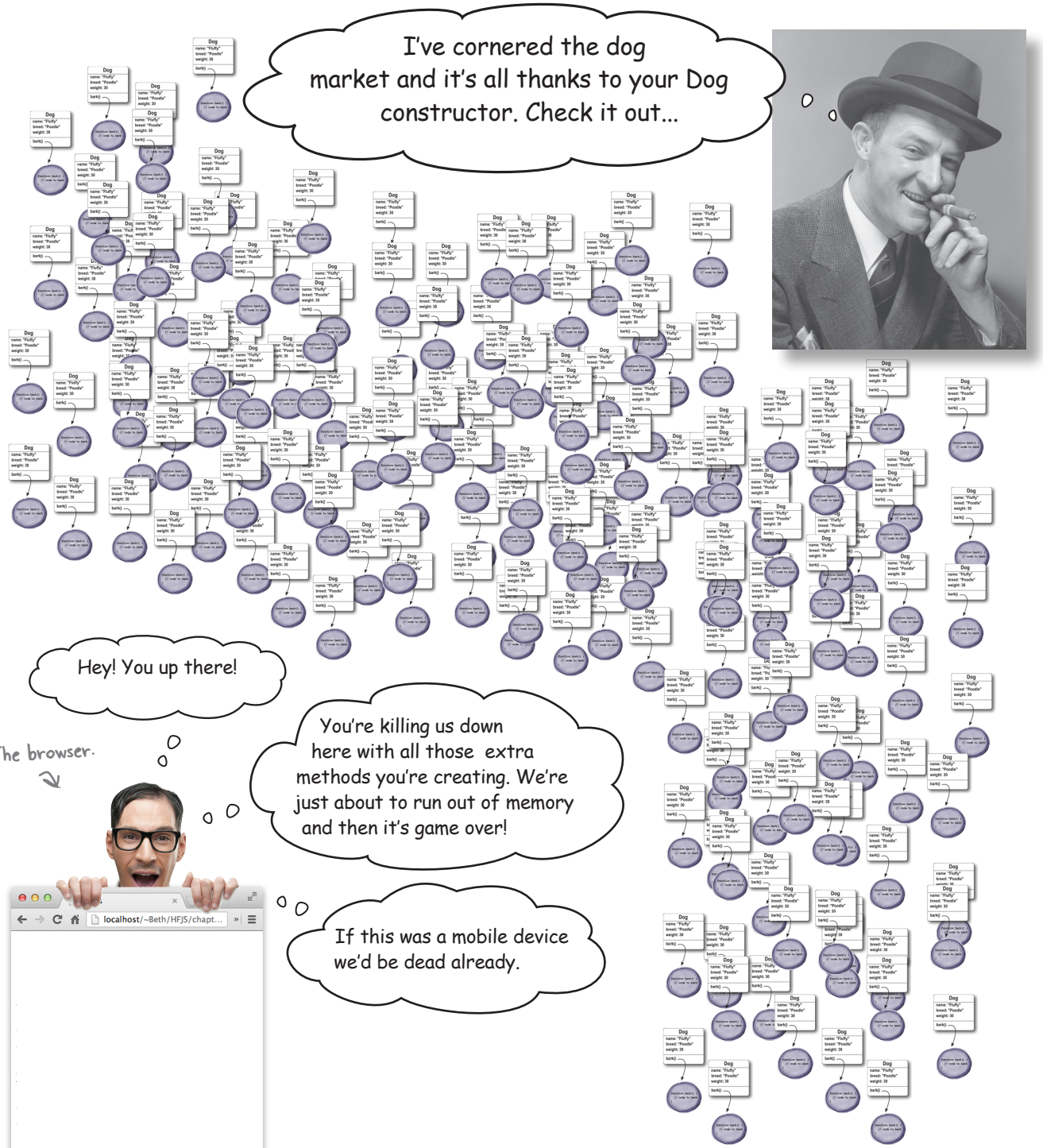
Even better, we're totally reusing code across all the dogs.

So by using the constructor we get a nice, consistent dog object that we can customize to our liking, and, we also can leverage the methods that are defined in it (in this case there's only one, `bark`). Further, every dog gets the same code from the constructor, saving us lots of code headaches if things change in the future. That's all great, but let's look at what happens at runtime when we evaluate the code below:

```
var fido = new Dog("Fido", "Mixed", 38);
var fluffy = new Dog("Fluffy", "Poodle", 30);
var spot = new Dog("Spot", "Chihuahua", 10);
```

This code causes three dog objects to be created. Let's use our new object diagrams to see what that looks like:




I've cornered the dog market and it's all thanks to your Dog constructor. Check it out...
Hey! You up there!
The browser.
You're killing us down here with all those extra methods you're creating. We're just about to run out of memory and then it's game over!
If this was a mobile device we'd be dead already.
localhost/~Beth/HFJS/chapt...

Is duplicating methods really a problem?

Actually, it is. In general we don't want a new set of methods being created every time you instantiate an object with a constructor. Doing so hurts the performance of your application and impacts resources on your computer, which can be a big deal, particularly on mobile devices. And, as you're going to see, there are more flexible and powerful ways to craft your JavaScript objects.

Let's take a step back and think about one of the main reasons we used constructors in the first place: we were trying to *reuse behavior*. For instance, remember that we had a bunch of dog objects and we wanted all those objects to use the same `bark` method. By using a constructor we achieved this at a code level by placing the `bark` method in one place—inside the Dog constructor—and so we reused the same `bark` code each time we instantiated an object. But, our solution doesn't look as promising at runtime because every dog instance is getting its own copy of the `bark` method.

Typically when we talk about an object's "behavior" we're referring to the set of methods it supports.

Now the reason we're running into this problem is because we aren't taking full advantage of JavaScript's object model, which is based on the idea of *prototypes*. In this model, we can create objects that are extensions of other objects—that is, of prototype objects.

To demonstrate prototypes, hmm… if only we had a *dog prototype* around that we could work from…

What are prototypes?

JavaScript objects can inherit properties and behavior from other objects. More specifically, JavaScript uses what is known as *prototypal inheritance*, and the object you're inheriting behavior from is called the *prototype*. The whole point of this scheme is to inherit and reuse existing properties (including methods), while extending those properties in your brand new object. That's all quite abstract so let's work through an example.

When an object inherits from another, it gains access to all its methods and properties.

We'll start with a prototype for a dog object. Here's what it might look like:

I'm the dog prototype. I've got properties that every dog needs and you can use me as a prototype for any dog you want to create.

Here's a prototype for dogs. This is an object that contains properties and methods that all dogs might need.

The prototype doesn't include name, breed or weight because those will be unique to each dog, and supplied by the real dogs that inherit from the prototype.

Dog Prototype

species: "Canine"

bark()
run()
wag()

Contains properties useful to every dog.

Contains behavior we'd like to use in all dogs that we create.

So now that we have a good dog prototype, we can create dog objects that inherit properties from that prototype. Our dog objects will also extend the prototype properties with dog-specific properties or behaviors. For example, we know we'll be adding a name, breed and weight to each dog.

You'll see that if any of these dogs needs to bark, run or wag their tails, they can rely on the prototype for those behaviors, because they inherit them from the prototype. So, let's create a few dog objects so you can see how this all works.

Inheriting from a prototype

First, we need to create object diagrams for the Fido, Fluffy and Spot dog objects and have them inherit from the new dog prototype. We'll show inheritance by drawing a set of dashed lines from the dog instances to the prototype. And remember, we put only the methods and properties that are common to *all* dogs in the dog prototype, because *all* the dogs will inherit them. All the properties specific to an actual dog, like the dog's name, go into the dog instances, because they are different for each dog.

Dog Prototype

species: "Canine"

bark()
run()
wag()

← Properties and methods common to all dogs are here.

Here we have three dog objects that inherit from the dog prototype. The prototype contains properties (including methods) shared by all the dogs. The dogs themselves contain the properties specific to each dog: a name, breed and weight.

Read this dashed line as "inherits from."

Same with Fluffy.

And so on for each dog we create.

Dog

name: "Fido"
breed: "Mixed"
weight: 38

Dog

name: "Fluffy"
breed: "Poodle"
weight: 30

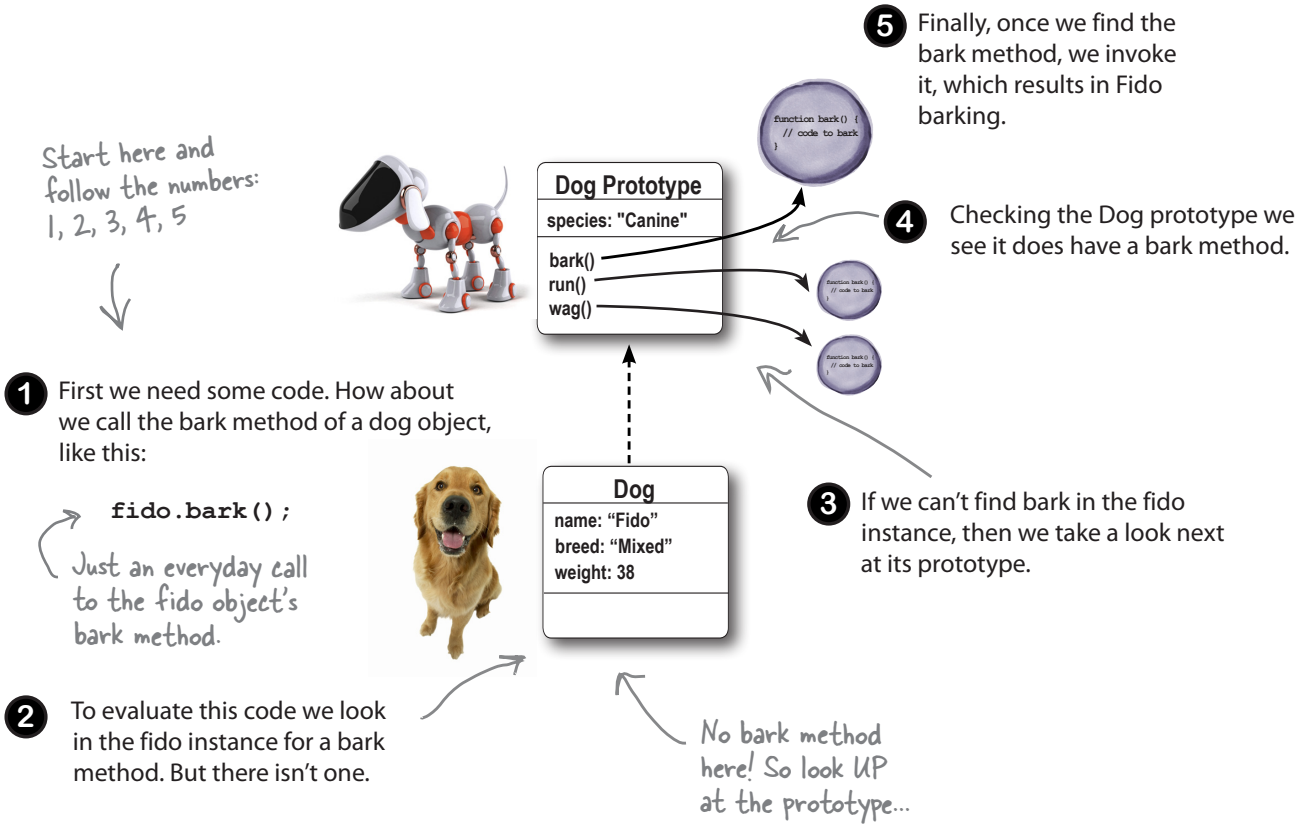
Dog

name: "Spot"
breed: "Chihuahua"
weight: 10

Fido only needs to contain the name, breed and weight.

How inheritance works

How do we make dogs bark if the `bark` method isn't in the individual dog instances, but rather is in the prototype? That's where inheritance comes in. When you call a method on an object instance, and that method isn't found in the instance, you check the prototype for that method. Here's how.

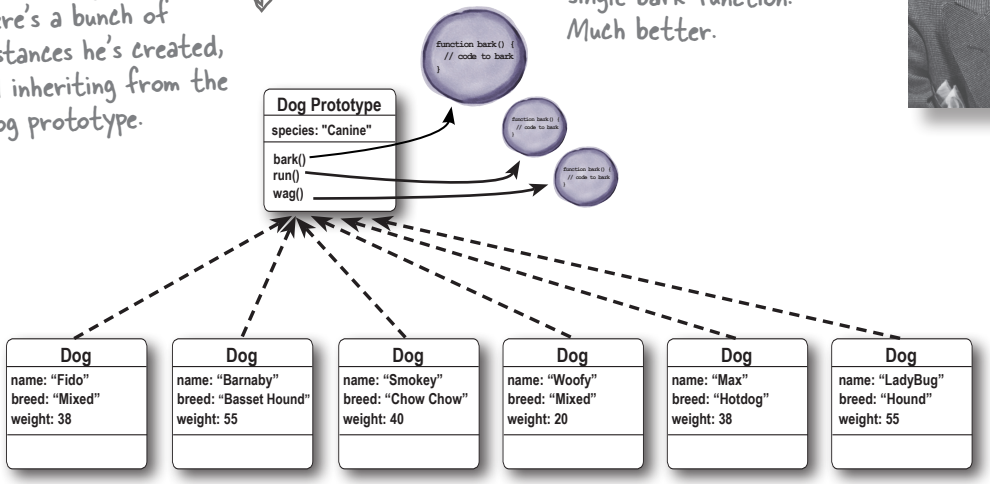


Properties work the same way. If we write code that needs `fido.name`, the value will come from the `fido` object. But if we want the value of `fido.species`, we first check the `fido` object, but when it isn't found there, we check the dog prototype (and find it).

So now that you have this newfangled inheritance thing, I can fire up the dog factory again?

He's started producing lots of dogs already. Here's a bunch of instances he's created, all inheriting from the dog prototype.

Now we only have a single bark function. Much better.

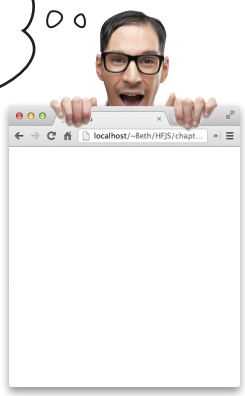


Every dog has been customized with its name, breed and weight, but relies on the prototype for the species property and the bark method.

Now that you understand how to use inheritance we can create a large number of dogs. All the dogs can all still bark, but now they're relying on the dog prototype object to supply that `bark` method. We have code reuse, not just by having our code written in one place, but by having all dog instances use the *same* bark method at runtime, which means we aren't causing lots of runtime overhead.

You're going to see that by using prototypes, you'll be able to quickly assemble objects that reuse code, and that can be extended with new behavior and properties.

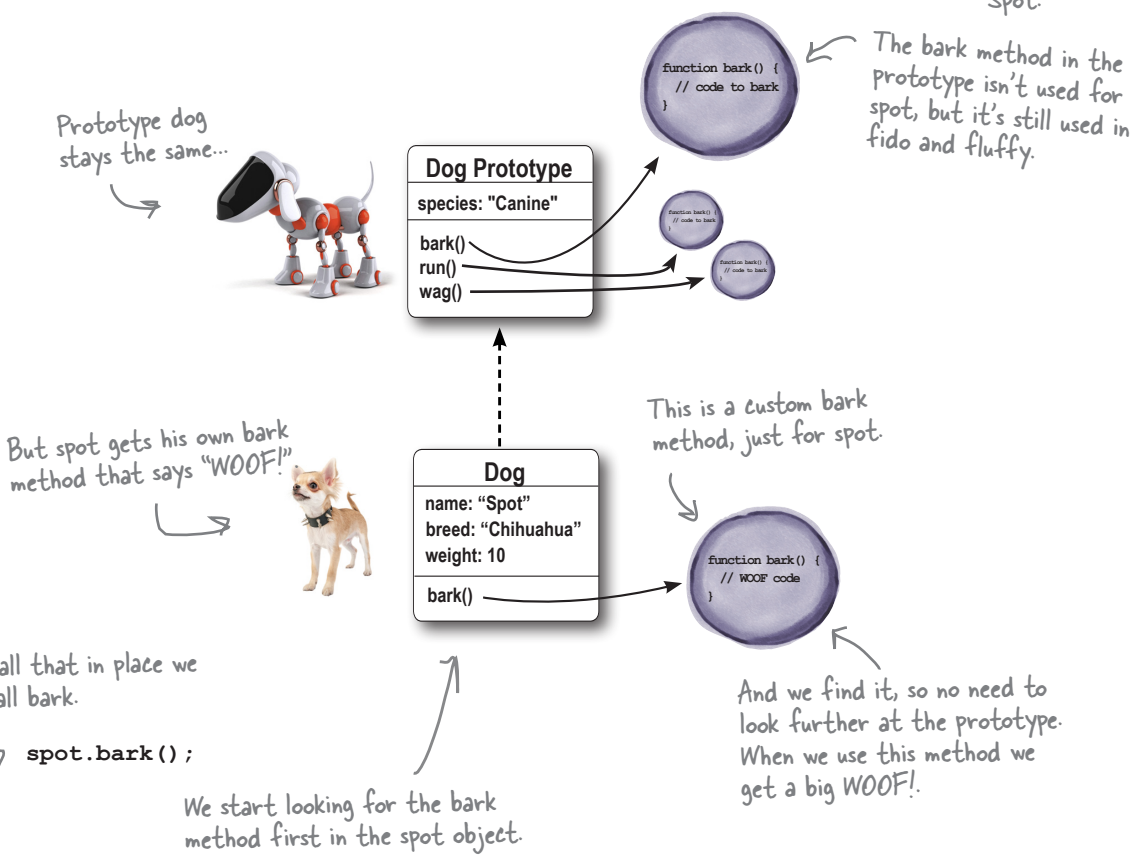
Thank you! Before you started using inheritance we were dying down here!



Overriding the prototype

Just because you inherit something from the prototype doesn't mean you're stuck with it. We can always *override* properties and methods by supplying them in the object instance. That works because JavaScript always looks in the object instance—that is, the specific dog object—for a property *before* it looks in the prototype. So, if you want to use a custom `bark` method for `spot`, all you have to do is put that custom `bark` method in the `spot` object. Once you do that, when JavaScript looks for the `bark` method to invoke, it will find the method in `spot`, and won't bother looking in the prototype.

Let's see what it looks like when we override Spot's `bark` method to give him the ability to have a big "WOOF" bark.



Code Magnets

We had an object diagram on the fridge, and then someone came and messed it up. Can you help put it back together? To reassemble it, we need two instances of the robot prototype. One is Robby, created in 1956, owned by Dr. Morbius, has an on/off switch and runs to Starbucks for coffee. We've also got Rosie, created in 1962, who cleans house and is owned by George Jetson. Good luck (oh, and there might be some extra magnets below)!

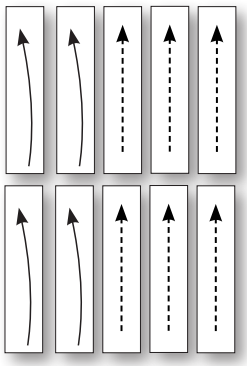
Here's the prototype your robots can inherit from.

Robot Prototype

maker: "ObjectsRUs"

speak()
makeCoffee()
blinkLights()

Build the object diagram here.



Robot
name: "Robby"

Robot
name: "Rosie"

owner: Dr. Morbius

owner: George Jetson

year: 1956

year: 1962

onOffSwitch: true

makeCoffee()

makeCoffee()

cleanHouse()

```
function blinkLights() {
  // code 4 lights
}
```

```
function cleanHouse() {
  // code 4 clean
}
```

```
function makeCoffee() {
  // code 4 coffee
}
```

```
function speak() {
  // code to speak
}
```

```
function makeCoffee() {
  // starbucks
}
```

So where do you get a prototype?

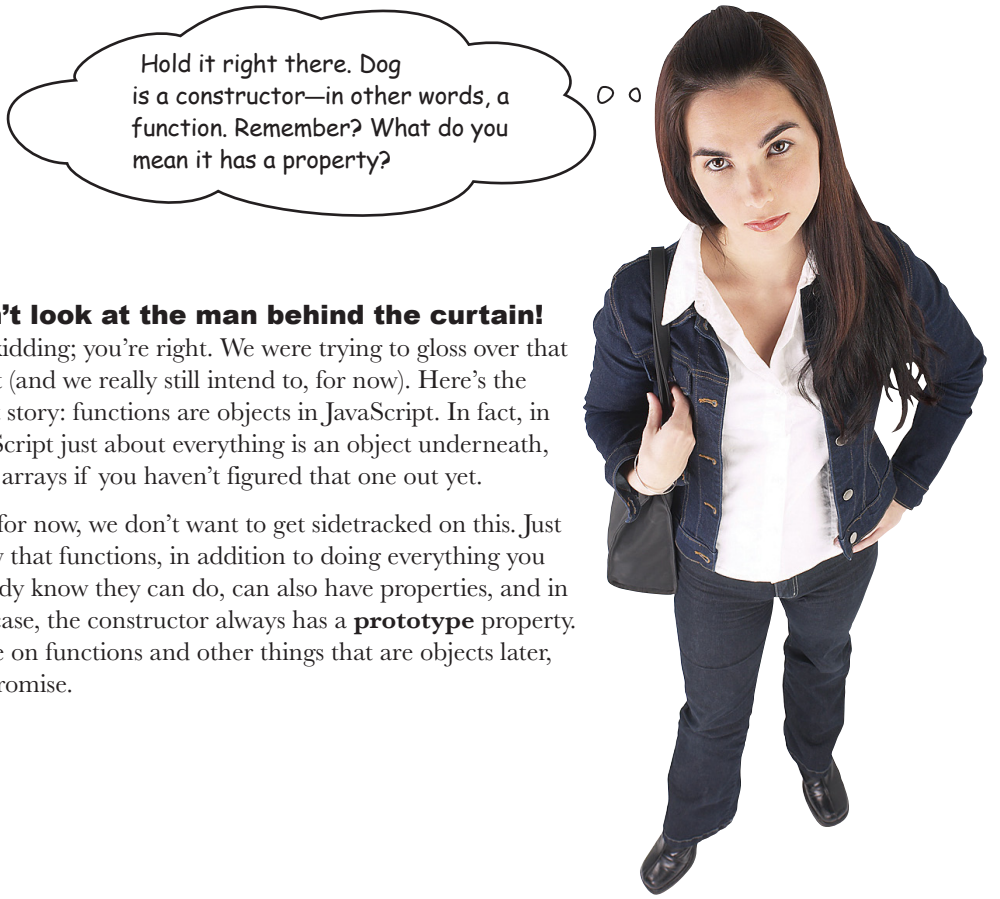
We've talked a lot about the dog prototype, and at this point, you're probably ready to see an example that uses code rather than diagrams. So, how do we create or get a hold of a dog prototype? Well, it turns out, you've actually had one all along. You just didn't know it.

And here's how you access it in code:

```
Dog.prototype
```

If you look at your Dog constructor, it has a prototype property that holds a reference to the actual prototype.

Now, if you take this `prototype` property…



Don't look at the man behind the curtain!

Just kidding; you're right. We were trying to gloss over that point (and we really still intend to, for now). Here's the short story: functions are objects in JavaScript. In fact, in JavaScript just about everything is an object underneath, even arrays if you haven't figured that one out yet.

But, for now, we don't want to get sidetracked on this. Just know that functions, in addition to doing everything you already know they can do, can also have properties, and in this case, the constructor always has a **prototype** property. More on functions and other things that are objects later, we promise.

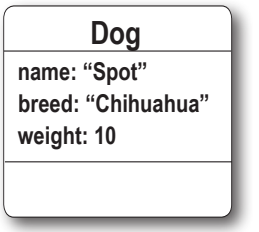
How to set up the prototype

As we were saying, you can access the prototype object through the Dog constructor's `prototype` property. But what properties and methods are in the prototype object? Well, until you set it up yourself, not much. In other words it's your job to add properties and methods to the prototype. We typically do that before we start using the constructor.

So, let's set up the dog prototype. First we need a constructor to work from, so let's look at our object diagram to see how to make that:

```
function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
}
```

This is the constructor to create an instance of a dog. Each instance has its own name, breed and weight., so let's incorporate those into the constructor.



But we're going to get our methods from the prototype, so we don't need them in the constructor.

Okay, now that we have a constructor, let's set up our dog prototype. We want it to have the `species` property and the `bark`, `run` and `wag` methods. Here's how we do that:

```
Dog.prototype.species = "Canine";

Dog.prototype.bark = function() {
    if (this.weight > 25) {
        console.log(this.name + " says Woof!");
    } else {
        console.log(this.name + " says Yip!");
    }
};

Dog.prototype.run = function() {
    console.log("Run!");
};

Dog.prototype.wag = function() {
    console.log("Wag!");
};
```

We assign the string "Canine" to the prototype's species property.

And for each method, we assign the appropriate function to the prototype's bark, run and wag properties respectively.

Serious Coding

Don't forget about chaining:

```
Dog.prototype.species
```

Start with Dog and grab its prototype property, which is a reference to an object that has a species property.

Test drive the prototype with some dogs

Go ahead and get this code typed into a file ("dog.html") and loaded into your browser for testing. We've reproduced all the code after the changes we made on the previous page, and added a bit of testing code. Make sure all your dogs bark, run and wag like they should.

```
function Dog(name, breed, weight) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
}

Dog.prototype.species = "Canine";

Dog.prototype.bark = function() {
    if (this.weight > 25) {
        console.log(this.name + " says Woof!");
    } else {
        console.log(this.name + " says Yip!");
    }
};

Dog.prototype.run = function() {
    console.log("Run!");
};

Dog.prototype.wag = function() {
    console.log("Wag!");
};

var fido = new Dog("Fido", "Mixed", 38);
var fluffy = new Dog("Fluffy", "Poodle", 30);
var spot = new Dog("Spot", "Chihuahua", 10);

fido.bark();
fido.run();
fido.wag();

fluffy.bark();
fluffy.run();
fluffy.wag();

spot.bark();
spot.run();
spot.wag();
```

Here's the Dog constructor.

And here's where we add properties and methods to the dog prototype.

We're adding one property and three methods to the prototype.

Now, we create the dogs like normal...

... and then we call the methods for each dog, just like normal. Each dog inherits the methods from the prototype.

But wait a second, didn't Spot want his bark to be WOOF!?

```
JavaScript console
Fido says Woof!
Run!
Wag!
Fluffy says Woof!
Run!
Wag!
Spot says Yip!
Run!
Wag!
```

Each dog is barking, running and wagging. Good.

Hey, don't forget about me. I requested a bigger WOOF!

Give Spot his WOOF! in code

Don't worry, we didn't forget about Spot. Spot requested a bigger WOOF! so we need to override the prototype to give him his own custom `bark` method. Let's update the code:

```
...
```

The rest of the code goes here. We're just saving trees, or bits, or our carbon footprint, or something...

```
var spot = new Dog("Spot", "Chihuahua", 10);

spot.bark = function() {
    console.log(this.name + " says WOOF!");
};

// calls to fido and fluffy are the same

spot.bark();
spot.run();
spot.wag();
```

The only change we make to the code is to give Spot his own custom bark method.

We don't need to change how we call Spot's bark method at all.

Test drive the custom bark method

Add the new code above and take it for a quick test drive…

```
JavaScript console
Fido says Woof!
Run!
Wag!
Fluffy says Woof!
Run!
Wag!
Spot says WOOF!
Run!
Wag!
```

Spot gets the WOOF! he wanted.

Exercise

Remember our object diagram for the Robby and Rosie robots? We're going to implement that now. We've already written a Robot constructor for you along with some test code. Your job is to set up the robot prototype and to implement the two robots. Make sure you run them through the test code.

Here's the basic Robot constructor. You still need to set up its prototype.

```
function Robot(name, year, owner) {
    this.name = name;
    this.year = year;
    this.owner = owner;
}
Robot.prototype.maker =

Robot.prototype.speak =

Robot.prototype.makeCoffee =

Robot.prototype.blinkLights =

var robby =
var rosie =

robby.onOffSwitch =
robby.makeCoffee =


rosie.cleanHouse =


console.log(robby.name + " was made by " + robby.maker +
            " in " + robby.year + " and is owned by " + robby.owner);
robby.makeCoffee();
robby.blinkLights();

console.log(rosie.name + " was made by " + rosie.maker +
            " in " + rosie.year + " and is owned by " + rosie.owner);
rosie.cleanHouse();
```

You'll want to set up the robot prototype here.

Write your code to create the Robby and Rosie robots here. Make sure you add any custom properties they have to the instances.

Use this code to test your instances to make sure they are working properly and inheriting from the prototype.

I was wondering how this.name in the bark method still works given that the bark method is in the prototype and not in the original object.

Good question. When we didn't have prototypes this was easy because we know `this` gets set to the object whose method was called. When we are calling the `bark` method in the prototype, you might think that `this` is now set to the prototype object. Well, that's not how it works.

When you call an object's method, `this` is set to the object whose method was called. If the method is not found in that object, and is found in the prototype, that doesn't change the value of `this`. `this` always refers to the original object—that is, the object whose method was called—even if the method is in the prototype. So, if we find the `bark` method in the prototype, then we call the method, with `this` set to the original dog object, giving us the result we want, like "Fluffy says Woof!".

Teaching all dogs a new trick

It's time to teach our dogs a new trick. That's right we said "dogs" plural, not dog. You see, now that we have a prototype, if we add any methods to that prototype, even after we've already created dog objects, all dogs inheriting from the prototype immediately and automatically get this new behavior.

Let's say we want to teach all our dogs to sit. What we do is add a method to the prototype for sitting.

```
var barnaby = new Dog("Barnaby", "Basset Hound", 55);

Dog.prototype.sit = function() {
    console.log(this.name + " is now sitting");
}
```

Let's create another dog to test this on.

And then let's add the sit method.

We'll give this a try with Barnaby:

```
barnaby.sit();
```

We first check to see if the barnaby object has a sit method and there isn't one. So we then check the prototype, find the sit method, and invoke it.

JavaScript console

```
Barnaby is now sitting
```

A Closer Look

Let's take a closer look at how this works. Make sure you follow the sequence 1, 2, 3, 4.

Dog Prototype

species: "Canine"

bark()
run()
wag()
sit()



2 Next we add a new method, `sit`, to the prototype.

```
function sit() {
  // code to sit
}
```

3 We call the `barnaby.sit` method, but we can't find `sit` in barnaby object.

Dog

name: "Barnaby"
breed: "Basset Hound"
weight: 55

1 We create a new dog Barnaby.

4 But we do find `sit` in the prototype, and we invoke it.

Prototypes are dynamic

We're glad to see Barnaby can now sit. But it turns out that now *all* our dogs can sit, because once you add a method to a prototype, any objects that inherit from that prototype can make use of that method:

This works for properties too, of course.

Any dog object that has the Dog prototype can now use the sit method.

there are no Dumb Questions

Q: So when I add a new method or property to a prototype, all the object instances that inherit from it immediately see it?

A: If by "see it" you mean that they inherit that method or property, you are correct. Notice that this gives you a way to extend or change the behavior of all your instances at runtime by simply changing their prototype.

Q: I see how adding a new property to a prototype makes that property available to all the objects that inherit from the prototype. What if I *change* an existing property in the prototype; does that affect those objects in the same way? Like if I change the property species to "Feline" instead of "Canine", does that mean all existing dogs are now "Feline" species?

A: Yes. If you change any property in the prototype, it affects all the objects that inherit from that prototype, unless that object has overridden that property.

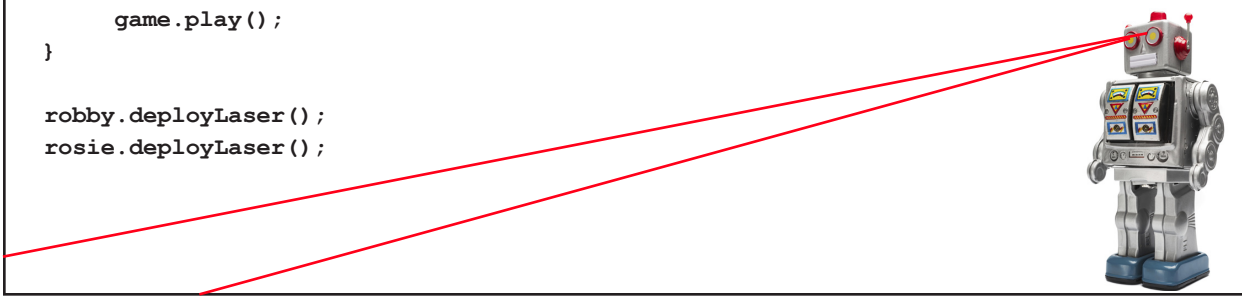
Robby and Rosie are being used in a Robot game. You'll find the code for them below. In this game, whenever a player reaches level 42, a new robot capability is unlocked: the laser beam capability. Finish the code below so that at level 42 both Robby and Rosie get their laser beams. Check your answer at the end of the chapter before you go on.

```
function Game() {
    this.level = 0;
}

Game.prototype.play = function() {
    // player plays game here
    this.level++;
    console.log("Welcome to level " + this.level);
    this.unlock();
}

Game.prototype.unlock = function() {









}

function Robot(name, year, owner) {
    this.name = name;
    this.year = year;
    this.owner = owner;
}

var game = new Game();
var robby = new Robot("Robby", 1956, "Dr. Morbius");
var rosie = new Robot("Rosie", 1962, "George Jetson");

while (game.level < 42) {
     game.play();
}

robby.deploylaser();
rosie.deploylaser();
```

JavaScript console

```
Welcome to level 1
Welcome to level 2
Welcome to level 3
 ...
Welcome to level 41
Welcome to level 42
Rosie is blasting you with
laser beams.
```

A sample of our output. When you finish your code, give it a play and see which robot wins and gets to blast its laser beams!



A more interesting implementation of the sit method

Let's make the `sit` method a little more interesting: dogs will start in a state of not sitting (in other words, standing up). So, when `sit` is called, if a dog isn't sitting, we'll make him sit. Otherwise, we'll let the user know he's already sitting. To do this we're going to need an extra property, `sitting`, to keep track of whether the dog is sitting or not. Let's write the code:

We start with a sitting property in the prototype.

By setting sitting to false in the prototype, all dogs start by not sitting.

Then, in the sit method, we check to see if the dog is sitting or not. At first, when we check this.sitting we'll be looking at the value in the dog prototype.

```
Dog.prototype.sitting = false;

Dog.prototype.sit = function() {
    if (this.sitting) {
        console.log(this.name + " is already sitting");
    } else {
        this.sitting = true;
        console.log(this.name + " is now sitting");
    }
};
```

If the dog is sitting, we say he's already sitting.

But, if the dog is not sitting, we say he's now sitting and then we set the value of this.sitting to true. This overrides the prototype property and sets the value in the instance.

Notice that the instance now has its own local sitting property, set to true.

The interesting thing about this code is that when a dog instance starts out life, it inherits a default value of false for `sitting`. But, as soon as the `sit` method is called, the dog instance adds its own value for sitting, which results in a property being created in the instance. This overrides the inherited `sitting` property in the prototype. This gives us a way to have a default for all dogs, and then to specialize each dog if we need to.

Test drive the new sit method

Let's give this a try for real. Go ahead and update your code, adding the new property and implementation of `sit`. Now when we test drive this code, you can see that we can make `barnaby` sit, and then make `spot` sit, and each dog keeps track of whether it is sitting separately:

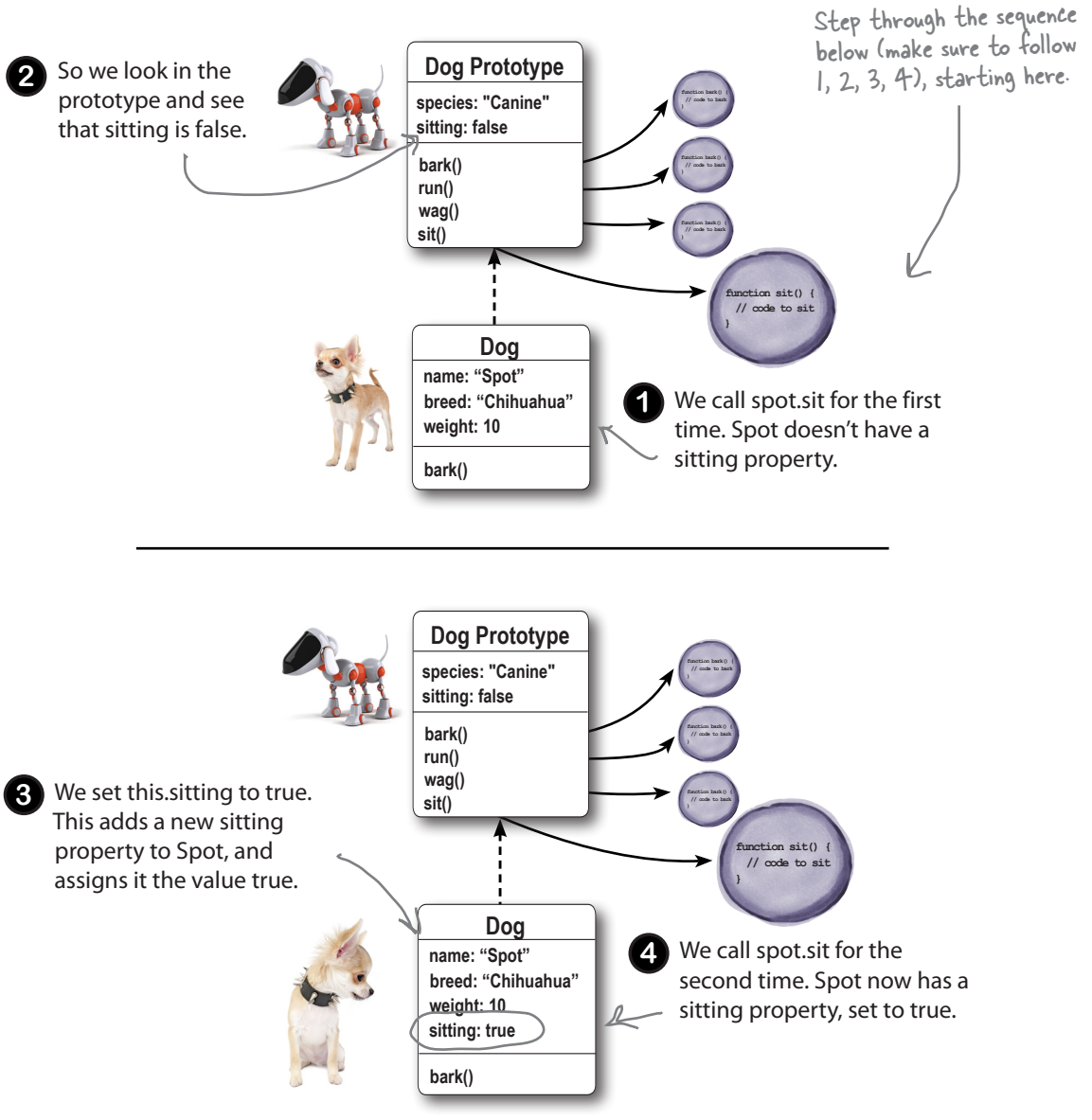
```
barnaby.sit()
barnaby.sit()
spot.sit()
spot.sit()
```

JavaScript console

```
Barnaby is now sitting
Barnaby is already sitting
Spot is now sitting
Spot is already sitting
```

One more time: how the sitting property works

Let's make sure we've got this down, because if you go too fast on this implementation you might miss the key details. Here's the key: the first time we get the value of `sitting`, we're getting it from the prototype. But then when we set `sitting` to true, that happens in the object instance, not the prototype. And after that property has been added to the object instance, every subsequent time we get the value of `sitting`, we're getting it from the object instance because it is overriding the value in the prototype. Let's step through it one more time:



While we're talking about properties, is there a way in my code to determine if I'm using a property that's in the instance or in the prototype?

Yes, there is. You can use the `hasOwnProperty` method that every object has. The `hasOwnProperty` method returns true if a property is defined in an object instance. If it's not, but you can access that property, then you can assume the property must be defined in the object's prototype.

Let's try it on `fido` and `spot`. First, we know that the species property is implemented only in the dog prototype, and neither `spot` nor `fido` has overridden this property. So if we call the `hasOwnProperty` method and pass in the property name, "species", as a string, we get back false for both:

```
spot.hasOwnProperty("species");
fido.hasOwnProperty("species");
```

Both of these return the value false because species is defined in the prototype, not the object instances spot and fido.

Now let's try it for the `sitting` property. We know that the `sitting` property is defined in the prototype and initialized to false. So we assign the value true to `spot.sitting`, which overrides the `sitting` property in the prototype and defines sitting in the `spot` instance. Then we'll ask both `spot` and `fido` if they have their own `sitting` property defined:

When we first check to see if Spot has his own sitting property we get false.

```
spot.hasOwnProperty("sitting");
spot.sitting = true;
spot.hasOwnProperty("sitting");

fido.hasOwnProperty("sitting");
```

Then we set spot.sitting to true, adding this property to the spot instance.

This call to hasOwnProperty returns true, because spot now has his own sitting property.

But this call to hasOwnProperty returns false, because the fido instance does not have a sitting property. That means the sitting property that fido uses is defined only in the prototype, and inherited by fido.

We've added a new capability to our robots, Robby and Rosie: they can now report when they have an error through the reportError method. Trace the code below, paying particular attention to where this method gets its error information, and to whether it's coming from the prototype of the robot instance.

Below give the output of this code:

```
function Robot(name, year, owner) {
    this.name = name;
    this.year = year;
    this.owner = owner;
}

Robot.prototype.maker = "ObjectsRUs";
Robot.prototype.errorMessage = "All systems go.";
Robot.prototype.reportError = function() {
    console.log(this.name + " says " + this.errorMessage);
};
Robot.prototype.spillWater = function() {
    this.errorMessage = "I appear to have a short circuit!";
};

var robby = new Robot("Robby", 1956, "Dr. Morbius");
var rosie = new Robot("Rosie", 1962, "George Jetson");

rosie.reportError();
robby.reportError();
robby.spillWater();
rosie.reportError();
robby.reportError();

console.log(robby.hasOwnProperty("errorMessage"));
console.log(rosie.hasOwnProperty("errorMessage"));
```

Does Robby have his own errorMessage property?

Does Rosie?

Best Dog in Show

All your hard work in this chapter has already paid off. The Webville Kennel Club saw your work on the dog objects and they immediately knew they'd found the right person to implement their dog show simulator. The only thing is they need you to update the Dog constructor to make show dogs. After all, show dogs aren't ordinary dogs—they don't just run, they gait. They don't go through the trash, they show a tendency towards scent articles; they don't beg for treats, they show a desire for bait.

More specifically, here's what they're looking for:

Wonderful work on the Dog constructor! We'd love to get you engaged on our dog show simulator. Show dogs are a little different, so they need additional methods (see below).

Thanks! –Webville Kennel Club

stack() – otherwise known as stand at attention.

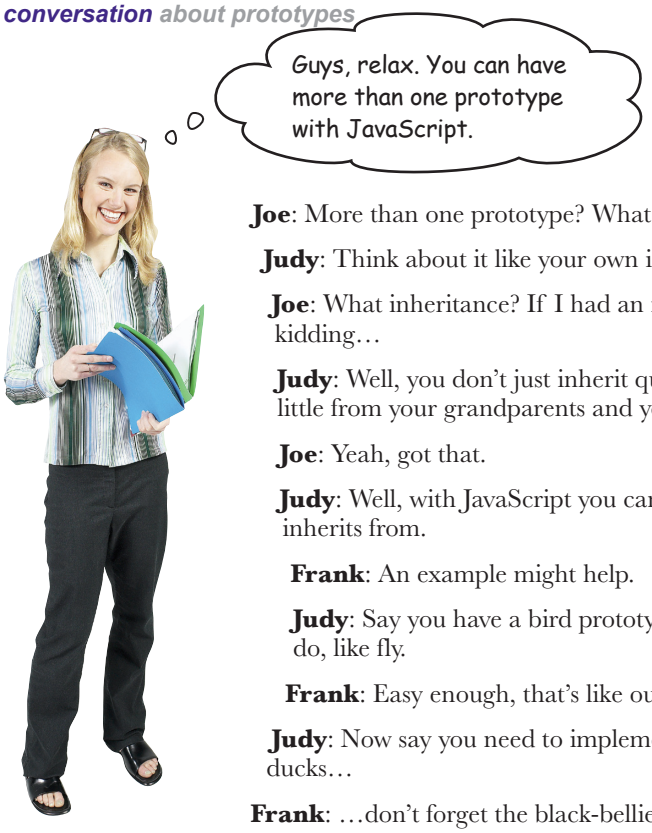
gait() – this is like running. The method takes a string argument of "walk", "trot", "pace", or "gallop".

bait() – give the dog a treat.

groom() – doggie shampoo time.

How to approach the design of the show dogs

So how are we going to design this? Clearly we'd like to make use of our existing dog code. After all, that's why Webville Kennel came to us in the first place. But how? Let's get some thoughts on the ways we could approach this:



Joe: More than one prototype? What does that even mean?

Judy: Think about it like your own inheritance.

Joe: What inheritance? If I had an inheritance I wouldn't be working here! Just kidding…

Judy: Well, you don't just inherit qualities from your parents, right? You inherit a little from your grandparents and your great-grandparents and so on.

Joe: Yeah, got that.

Judy: Well, with JavaScript you can set up a chain of prototypes that your object inherits from.

Frank: An example might help.

Judy: Say you have a bird prototype that knows how to do all things most birds do, like fly.

Frank: Easy enough, that's like our dog prototype.

Judy: Now say you need to implement a whole set of ducks—mallards, red-headed ducks…

Frank: …don't forget the black-bellied-whistling duck.

Judy: Why, thank you Frank.

Frank: No problem. I was just reading about all those ducks in that *Head First Design Patterns* book.

Judy: Okay, but ducks are a different kind of bird. They swim, and we don't want to put that into the bird prototype. But with JavaScript we can create a duck prototype that inherits from the bird prototype.

Joe: So let me see if I have this right. We'd have a Duck constuctor that points to a duck prototype. But that prototype—that is the duck prototype—would itself point to the bird prototype?

Frank: Whoa, shift back into first gear.

Judy: Think of it like this, Frank. Say you create a duck and you call its `fly` method. What happens if you look in the duck and there's no such method? You look in the duck prototype, still no fly method. So you look at the prototype the duck inherits from, bird, and you find `fly` there.

Joe: And, if we call `swim`, then we look in the duck instance, nothing there. We look in the duck prototype, and we find it.

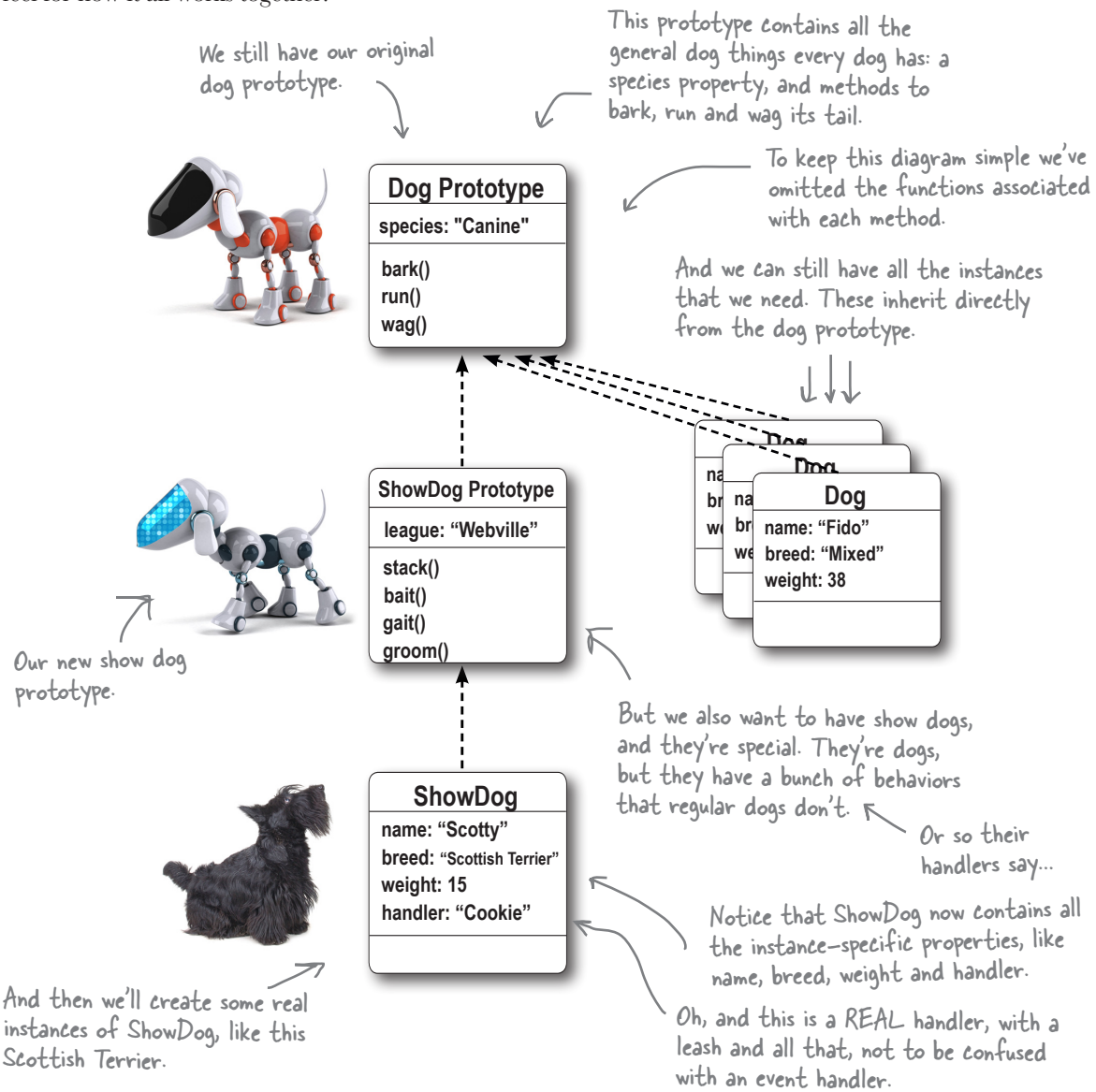
Judy: Right… so we're not just reusing the behavior of the duck prototype, we're following a chain up to the bird prototype, when necessary, to use that as well.

Joe: That sounds perfect for extending our dog prototype into a show dog. Let see what we can do with this.

Setting up a chain of prototypes

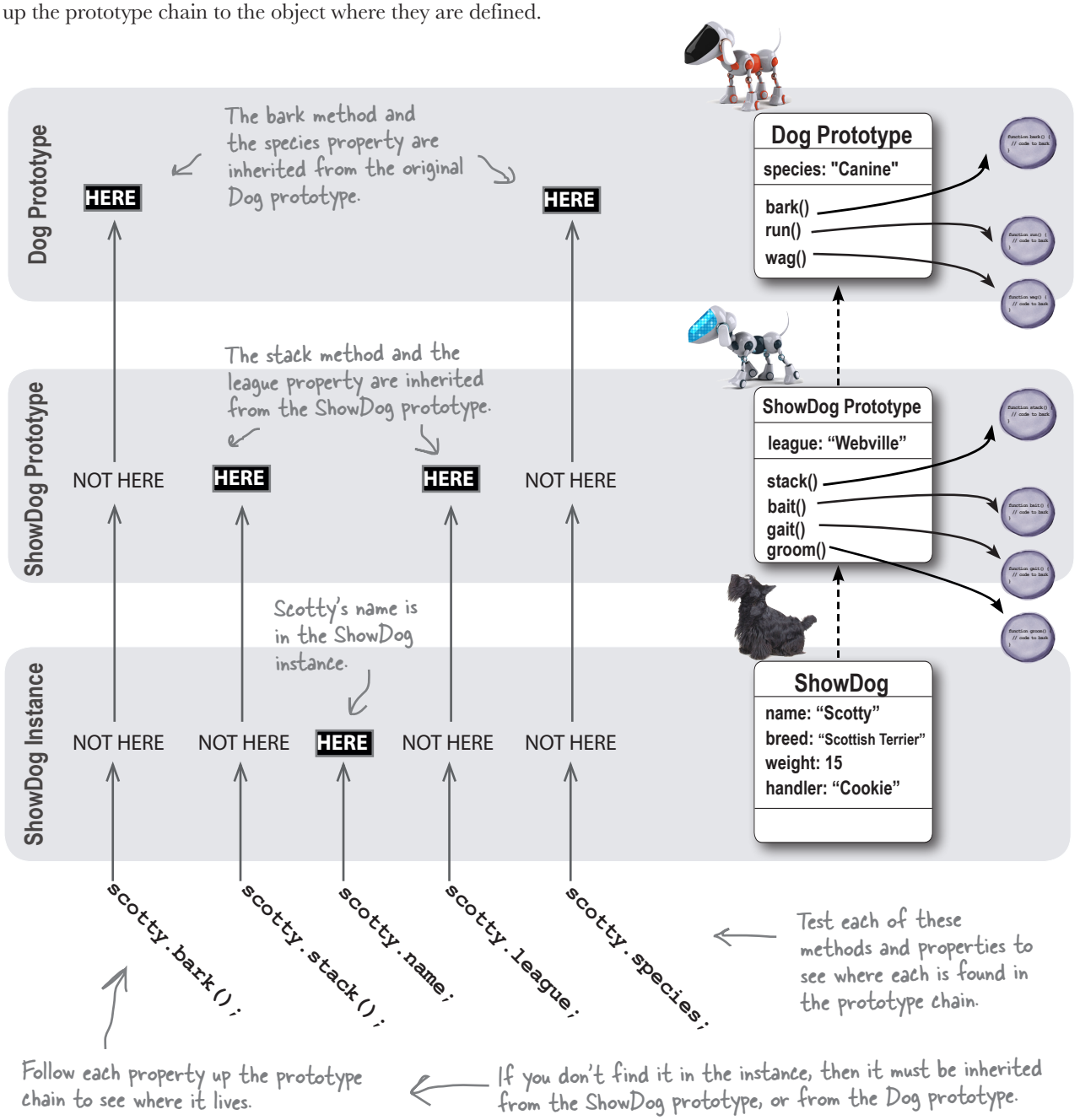
Let's start thinking in terms of a *chain of prototypes*. Rather than having an instance that inherits properties from just one prototype, there might be a chain of one or more prototypes your instance can inherit from. It's not that big a logical step from the way we've been thinking about this already.

Let's say we want a show dog prototype for our show dogs, and we want that prototype to rely on our original dog prototype for the `bark`, `run`, and `wag` methods. Let's set that up to get a feel for how it all works together:



How inheritance works in a prototype chain

We've set up the prototype chain for the show dogs, so let's see how inheritance works in this context. Check out the properties and methods at the bottom of the page, and then trace them up the prototype chain to the object where they are defined.



Code Magnets

We had another object diagram on the fridge, and then someone came and messed it up. Again!! Can you help put it back together? To reassemble it we need a new line of Space Robots that inherit properties from Robots. These new Space Robots override the Robot's speaking functionality, and extend Robots with piloting functionality and a new property, homePlanet. Good luck (there might be some extra magnets below)!

Build the object diagram here.

Here's the prototype for Robots.

Robot Prototype

maker: "ObjectsRUs"

speak()
makeCoffee()
blinkLights()

```
function speak() {
  // code
}
```

```
function makeCoffee() {
  // code 4
}
```

```
function blinklights() {
  // code 4 lights
}
```

Robot

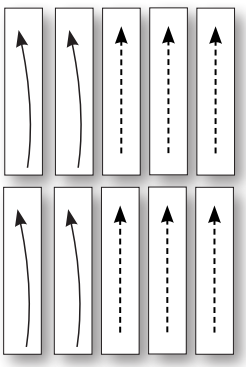
name: "Robby"
year: 1956
owner: "Dr. Morbius"

Robot

name: "Rosie"
year: 1962
owner: "George Jetson"

And here's the prototype for the Space Robots.

Space Robot Prototype



speak()

year: 1977

pilot()

year: 2009

homePlanet: "Earth"

homePlanet: "Tatooine"

```
function speak() {
  // code to speak
  in space
}
```

```
function
pilot() {
  // code to pilot
  spaceship
}
```

Space Robot

name: "C3PO"
year: 1977
owner: "L. Skywalker"

Space Robot

name: "Simon"
year: 2009
owner: "Carla Diana"

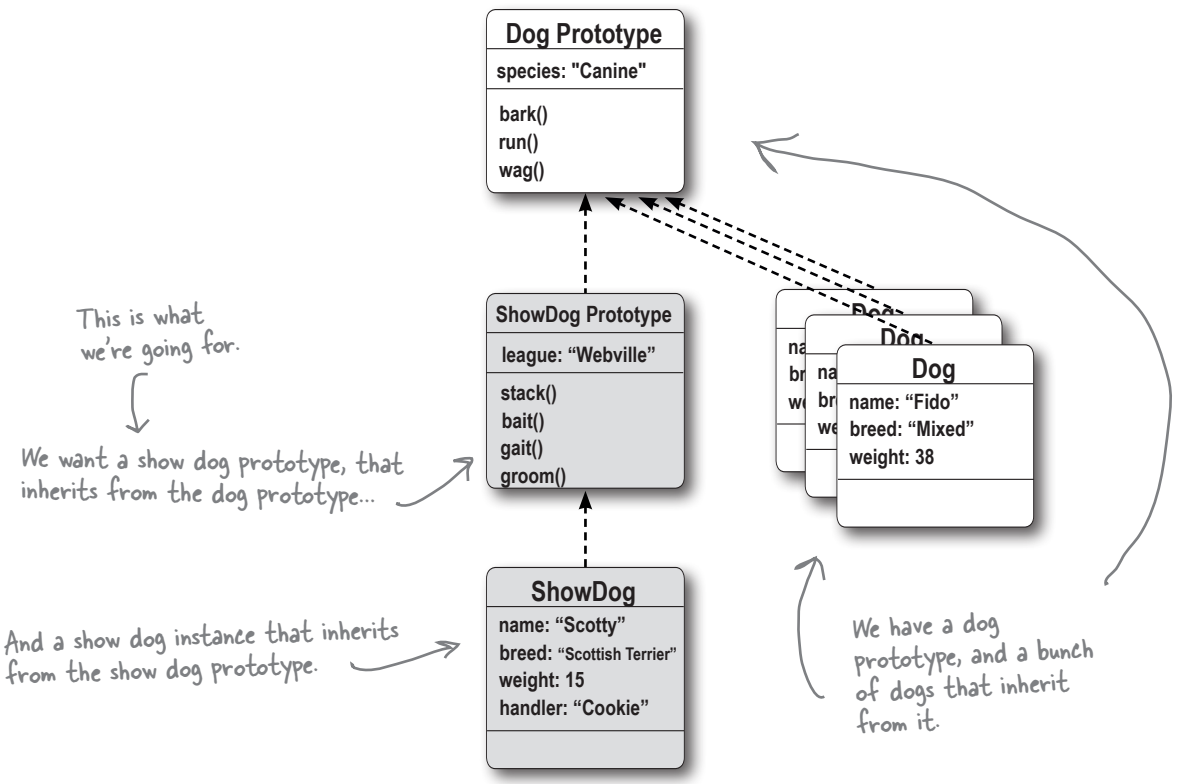
Creating the show dog prototype

When we created the dog prototype we didn't have to do anything—there was already an empty object supplied by the Dog constructor's `prototype` property. So we took that and added the properties and methods we wanted our dog instances to inherit.

But with the show dog prototype we have more work to do because we need a prototype object that inherits from another prototype (the dog prototype). To do that we're going to have to create an object that inherits from the dog prototype and then explicitly wire things up ourselves.

Right now we have a dog prototype and a bunch of dog instances that inherit from that prototype. And what we want is a show dog prototype (that inherits from dog prototype), and a bunch of show dog instances that inherit from the show dog prototype.

Setting this up will take a few steps, so we'll take it one at a time.



First, we need an object that inherits from the dog prototype

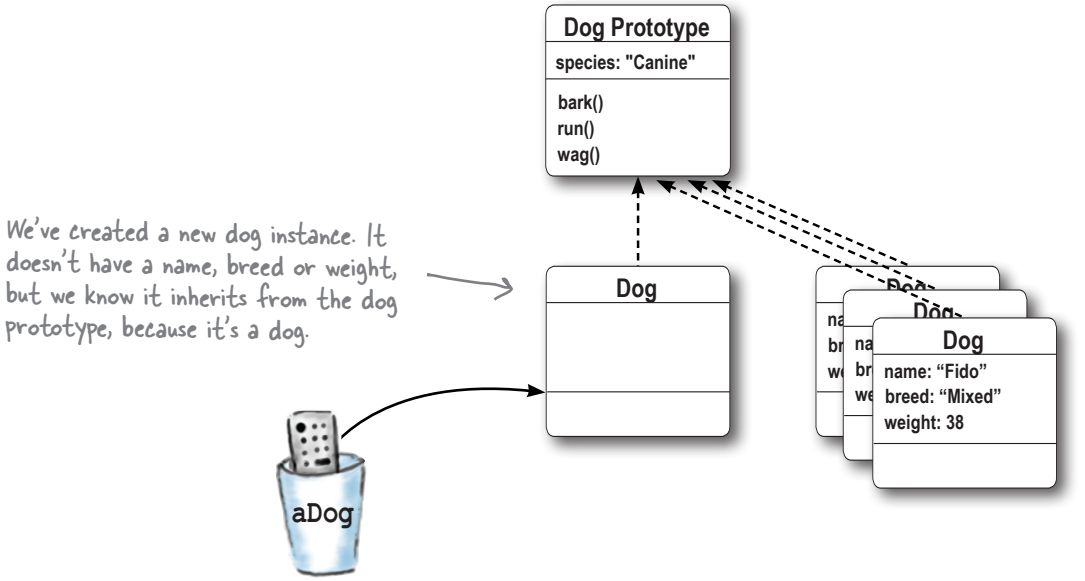
We've established that the show dog prototype is an object that inherits from the dog prototype. But, what's the best way to create an object that inherits from the dog prototype? Well, it's something you've already been doing as you've created instances of dog. Remember? Like this:

To create an object that inherits from the dog prototype, we just use new with the Dog constructor.

```
var aDog = new Dog();
```

We'll talk about what happened to the constructor arguments in a minute...

So this code creates an object that inherits from the dog prototype. We know this because it's exactly the same as how we created all our dog instances, except this time, we didn't supply any arguments to the constructor. That's because at the moment, we don't care about the specifics of the dog; we just need the dog to inherit from the dog prototype.



Now, what we really need is a show dog prototype. Like our dog instance, that's just an object that inherits from the dog prototype. So let's see how we can use our empty dog instance to make the show dog prototype we need.

Next, turning our dog instance into a show dog prototype

Okay, so we have a dog instance, but how do we make that our show dog prototype object? We do this by assigning the dog instance to the `prototype` property of our ShowDog constructor. Oh wait; we don't have a ShowDog constructor yet... so let's make one:

```
function ShowDog(name, breed, weight, handler) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.handler = handler;
}
```

This constructor takes everything we need to be a dog (name, breed, weight), and to be a show dog (a handler).

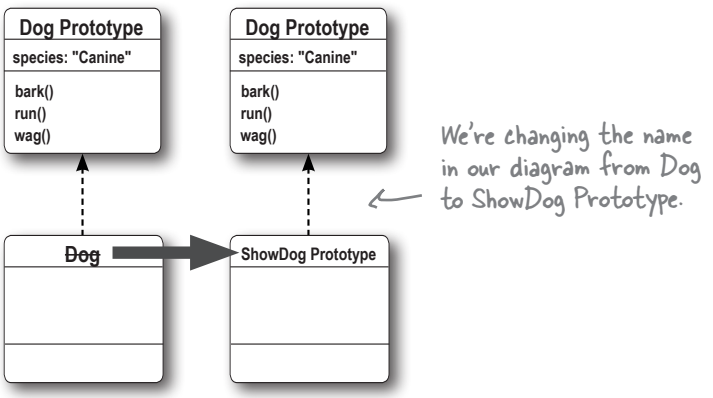
Now that we have a constructor, we can set its `prototype` property to a new dog instance:

```
ShowDog.prototype = new Dog();
```

We could have used our dog instance created on the previous page, but we can skip the variable assignment and just assign the new dog straight to the prototype property instead.

So, let's think about where we are: we have a ShowDog constructor, with which we can make show dog instances, and we now have a show dog prototype, which is a dog instance.

Let's make sure our object diagram accurately reflects the roles these objects are playing by changing the label "Dog" to "ShowDog Prototype". But keep in mind, the show dog prototype *is still a dog instance.*



Now that we've got a ShowDog constructor and we've set up the show dog prototype object, we need to go back and fill in some details. We'll take a closer look at the constructor, and we've also got some properties and methods to add to the prototype so our show dogs have the additional show dog behavior we want them to have.

Now it's time to fill in the prototype

We've got the show dog prototype set up (which at the moment is just an empty instance of dog). Now, it's time to fill it with properties and behaviors that will make it look more like a show dog prototype.

Here are some properties and methods that are specific to show dogs we can add:

```
function ShowDog(name, breed, weight, handler) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.handler = handler;
}

ShowDog.prototype = new Dog();

Showdog.prototype.league = "Webville";

ShowDog.prototype.stack = function() {
       console.log("Stack");
};

ShowDog.prototype.bait = function() {
       console.log("Bait");
};

ShowDog.prototype.gait = function(kind) {
       console.log(kind + "ing");
};

ShowDog.prototype.groom = function() {
       console.log("Groom");
};
```

Remember, the ShowDog constructor looks a lot like the Dog constructor. A show dog needs a name, breed, weight, plus one extra property, a handler (the person who handles the show dog). These will end up being defined in the show dog instance.

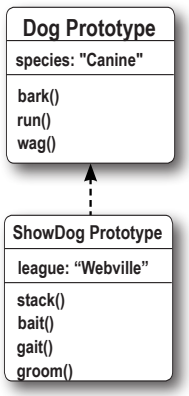
All our show dogs are in the Webville league, so we'll add this property to the prototype.

Here are all the methods we need for show dogs. We'll just keep them simple for now.

We're adding all these properties to the show dog prototype so all show dogs inherit them.

This is where we're taking the dog instance that is acting as the show dog prototype, and we're adding new properties and methods.

With these additions our show dog prototype is starting to look like a show dog. Let's update our object diagram again, and then it's probably time to do a big test run of the show dogs. We're guessing Webville Kennel is going to be pretty excited to see these in action.



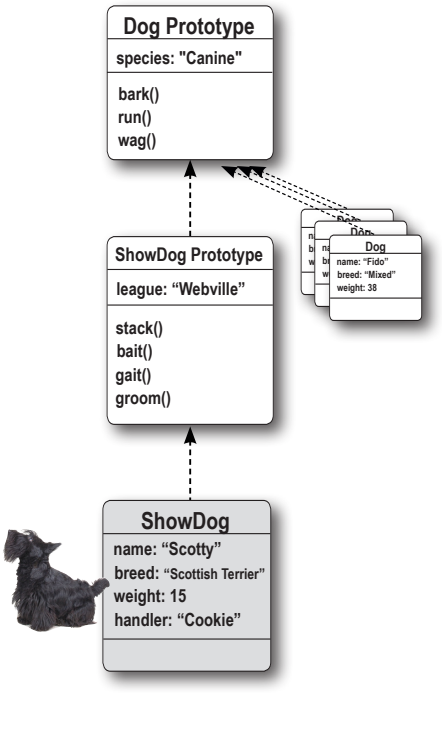
We say that our show dog prototype "extends" the dog prototype. It inherits properties from the dog prototype and extends it with new ones.

Creating a show dog instance

Now we just have one more thing to do: create an instance of ShowDog. This instance will inherit show dog properties and methods from our show dog prototype, and because our show dog prototype is an instance of Dog, the show dog will also inherit all its doggy behavior and properties from the dog prototype, so he'll be able to bark and run and wag with the rest of the dogs.

Here's all the code so far, and the code to create the instance:

```
function ShowDog(name, breed, weight, handler) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.handler = handler;
}

ShowDog.prototype = new Dog();

Showdog.prototype.league = "Webville";

ShowDog.prototype.stack = function() {
       console.log("Stack");
};

ShowDog.prototype.bait = function() {
       console.log("Bait");
};

ShowDog.prototype.gait = function(kind) {
       console.log(kind + "ing");
};

ShowDog.prototype.groom = function() {
       console.log("Groom");
};
```



And here's our show dog instance. It inherits from the show dog prototype, which inherits from the dog prototype. Just what we wanted. If you go back and look at page 592, you'll see we've completed the prototype chain.

Here's our new show dog, scotty.

```
var scotty = new ShowDog("Scotty", "Scottish Terrier", 15, "Cookie");
```

Test drive the show dog

Take all your the code on the previous page, and add to it the quality assurance code below, just to give scotty a good testing. Hey, and while you're at it, add a few dogs of your own and test them:

```
scotty.stack();
scotty.bark();
console.log(scotty.league);
console.log(scotty.species);
```

Here's what we got.

```
JavaScript console
Stack
Scotty says Yip!
Webville
Canine
```

Exercise

Your turn. Add a SpaceRobot line of robots to the ObjectsRUs line of robots. These robots should of course be able to do everything that robots can do, plus some extra behavior for space robots. We've started the code below, so finish it up and then test it. Check your answer at the end of the chapter before moving on.

```
function SpaceRobot(name, year, owner, homePlanet) {



}

SpaceRobot.prototype = new _____________;

  _____________________.speak = function() {
    alert(this.name + " says Sir, If I may venture an opinion...");
};

  _____________________.pilot = function() {
    alert(this.name + " says Thrusters? Are they important?");
};

var c3po = new SpaceRobot("C3PO", 1977, "Luke Skywalker", "Tatooine");
c3po.speak();
c3po.pilot();
console.log(c3po.name + " was made by " + c3po.maker);

var simon = new SpaceRobot("Simon", 2009, "Carla Diana", "Earth");
simon.makeCoffee();
simon.blinkLights();
simon.speak();
```

Exercise

Let's take a closer look at all these dogs we're creating. We've tested Fido before and we know he's truly a dog. But let's see if he's a show dog as well (we don't think he should be). And what about Scotty? We figure he should be a show dog for sure, but is he a dog too? We're not sure. And we'll test Fido and Scotty's constructors while we're at it...

```
var fido = new Dog("Fido", "Mixed", 38);
if (fido instanceof Dog) {
    console.log("Fido is a Dog");
}
if (fido instanceof ShowDog) {
    console.log("Fido is a ShowDog");
}

var scotty = new ShowDog("Scotty", "Scottish Terrier", 15, "Cookie");
if (scotty instanceof Dog) {
    console.log("Scotty is a Dog");
}
if (scotty instanceof ShowDog) {
    console.log("Scotty is a ShowDog");
}
console.log("Fido constructor is " + fido.constructor);
console.log("Scotty constructor is " + scotty.constructor);
```

Run this code and provide your output below.

Your output goes here:

JavaScript console

You'll find our output on the next page.

Examining the exercise results

Here's the output from that last test run:

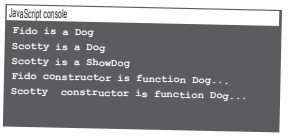
Fido is a dog, which we expected, and we don't see that Fido is a show dog, so he must not be one. That makes sense too.

And Scotty is both a dog and a show dog, which makes sense. But how does instanceof know that?

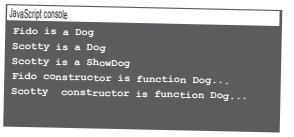
Hmm, this looks weird. Both Fido and Scotty show they were created by the dog constructor. But we used the show dog constructor to create Scotty...

```
JavaScript console
Fido is a Dog
Scotty is a Dog
Scotty is a ShowDog
Fido constructor is function Dog...
Scotty constructor is function Dog...
```

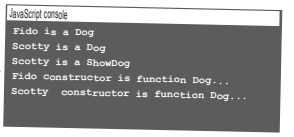
Let's think about these results for a minute. First, Fido is apparently just a dog and not a show dog—actually, that is totally what we thought would happen; after all, Fido was created with the Dog constructor, which has nothing to do with show dogs.



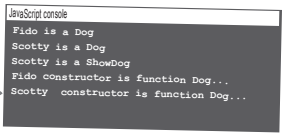
Next, Scotty is a dog *and* a show dog. That makes sense too, but how did this happen? Well, **instanceof** doesn't just look at what kind of object you are, it also takes into account all the objects you inherit from. So, Scotty was created as a show dog, but a show dog inherits from a dog, so Scotty is a dog too.



Next up, Fido has a Dog constuctor, and that makes sense, because that is how we created him.



And finally, Scotty has a Dog constructor too. That doesn't make sense, because Scotty was created by the ShowDog constructor. What's going on here? Well, first let's think about where this constructor comes from: we're looking at the `scotty.constructor` property, and this is something we've never setup. So we must be inheriting it from the dog prototype (again, because we haven't explicitly set it up for a show dog).



So why is this happening? Honestly, it's a loose end that we need to cleanup. You see, if we don't take care of setting the show dog prototype's `constructor` property, no one else will. Now, keep in mind everything is working fine without it; but not setting it could lead to confusion if you or someone else tries to use `scotty.constructor` expecting to get show dog.

But don't worry, we'll fix it.

A final cleanup of show dogs

Our code is just about ready to ship to Webville Kennel, but we need to make one final pass to polish it. There are two small issues to clean up.

The first, we've already seen: that instances of ShowDog don't have their constructor property set correctly. They're inheriting the Dog constructor property. Now, just to be clear, all our code works fine as is, but setting the right constructor on our objects is a best practice, and some day another developer may end up with your code and be confused when they examine a show dog object.

To fix the constructor property, we need to make sure it is set up correctly in the show dog prototype. That way, when a show dog is constructed it will inherit the right constructor property. Here's how we do that:

```
function ShowDog(name, breed, weight, handler) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.handler = handler;
}
ShowDog.prototype = new Dog();
ShowDog.prototype.constructor = ShowDog;
```

Here we're taking the show dog prototype and explicitly setting its constructor property to the ShowDog constructor.

Remember this is a best practice, without it your code still works as expected.

Note that we didn't have to do this for the dog prototype because it came with the constructor property set up correctly by default.

That's all you need to do. When we check Scotty again he should have the correct constructor property, as should all other show dogs.

Exercise

Quickly rerun the tests from the previous exercise and make sure your Scotty show dog instance has the correct constructor.

Here's what we got. Note that Scotty's constructor is now ShowDog.

JavaScript console

```
Fido is a Dog
Scotty is a Dog
Scotty is a ShowDog
Fido constructor is function Dog...
Scotty constructor is function ShowDog...
```

A little more cleanup

There's another place we could use some cleanup: in the ShowDog constructor code. Let's look again at the constructor:

```
function ShowDog(name, breed, weight, handler) {
    this.name = name;
    this.breed = breed;
    this.weight = weight;
    this.handler = handler;
}
```

If you didn't notice, this code is replicated from the Dog constructor.

As you've seen in this book, anytime we see duplicated code, the warning bells go off. In this case, the Dog constructor already knows how to do this work, so why not let the constructor do it? Further, while our example has simple code, at times constructors can have complex code to compute initial values for properties, and we don't want to start reproducing code everytime we create a new constructor that inherits from another prototype. So let's fix this. We'll rewrite the code first, and step you through it:

This idea of eliminating duplicate code even has an acronym: DRY. "Don't Repeat Yourself" as all the cool coders say.

```
function ShowDog(name, breed, weight, handler) {
    Dog.call(this, name, breed, weight);
    this.handler = handler;
}
```

This bit of code is going to reuse the Dog constructor code to process the name, breed, and weight.

But we still need to handle the handler in this code because the Dog constructor doesn't know anything about it.

As you can see we've replaced the redundant code in the ShowDog constructor with a call to a method named `Dog.call`. Here's how it works: `call` is a built-in method that you can use on any function (and remember Dog is a function). `Dog.call` invokes the Dog function and passes it the object to use as `this`, along with all the arguments for the Dog function. Let's break this down:

Dog is the function we're going to call.

Whatever is in this is used for this in the body of the Dog function.

The rest of the arguments are just passed to Dog like normal.

With this code we're calling the Dog constructor function but telling it to use our ShowDog instance as this, and so the Dog function will set the name, breed and weight properties in our ShowDog object.

```
Dog.call(this, name, breed, weight);
```

call is the method of Dog we're calling. The call method will cause the Dog function to be called. We use the call method instead of just calling Dog directly so we can control what the value of this is.

Stepping through Dog.call

Using `Dog.call` to call Dog is a bit tricky to wrap your head around so we'll walk through it again, starting with the reworked code.

```
function ShowDog(name, breed, weight, handler) {
    Dog.call(this, name, breed, weight);
    this.handler = handler;
}
```

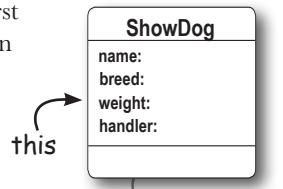
We're going to rely on the code from the Dog constructor to handle assigning the name, breed, and weight properties.

But Dog doesn't know anything about handler, so we have to take care of that in ShowDog.

Here's how to think about how this works. First, we call ShowDog with the `new` operator. Remember that the `new` operator makes a new, empty object, and assigns it to the variable `this` in the body of ShowDog.

```
var scotty = new ShowDog("Scotty", "Scottish Terrier", 15, "Cookie");
```

Then, we execute the body of the ShowDog constructor function. The first thing we do is call Dog, using the `call` method. That calls Dog, passing in `this`, and the `name`, `breed`, and `weight` parameters as arguments.

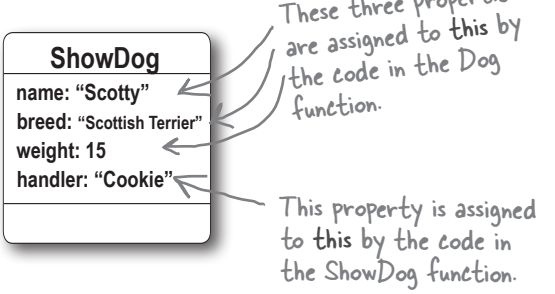



```
function ShowDog(name, breed, weight, handler) {
    Dog.call(this, name, breed, weight);

    function Dog(name, breed, weight) {
        this.name = name;
        this.breed = breed;
        this.weight = weight;
    }

    this.handler = handler;
}
```

We execute the body of Dog as normal, except that this is a ShowDog, not a Dog object.

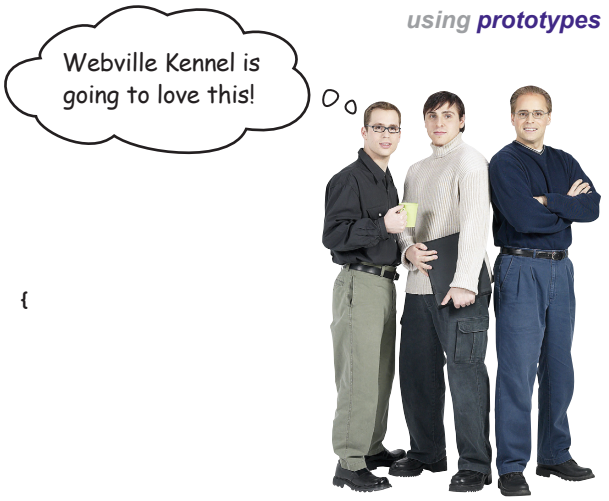
The this object created by new for ShowDog gets used as this in the body of Dog.

Once the Dog function completes (and remember, it is not going to return anything because we didn't call it with `new`), we complete the code in ShowDog, assigning the value of the parameter `handler` to the `this.handler` property. Then, because we used `new` to call ShowDog, an instance of ShowDog is returned, complete with its name, breed, weight, and handler.



The final test drive

Well done, you've created a fantastic design that we're sure Webville Kennel is going to love. Take all your dogs for one final test run so they can show off all their doggy capabilities.




```
function ShowDog(name, breed, weight, handler) {
    Dog.call(this, name, breed, weight);
    this.handler = handler;
}
ShowDog.prototype = new Dog();
ShowDog.prototype.constructor = ShowDog;
ShowDog.prototype.league = "Webville";
ShowDog.prototype.stack = function() {
    console.log("Stack");
};

ShowDog.prototype.bait = function() {
      console.log("Bait");
};
ShowDog.prototype.gait = function(kind) {
    console.log(kind + "ing");
};
ShowDog.prototype.groom = function() {
    console.log("Groom");
};
var fido = new Dog("Fido", "Mixed", 38);
var fluffy = new Dog("Fluffy", "Poodle", 30);
var spot = new Dog("Spot", "Chihuahua", 10);
var scotty = new ShowDog("Scotty", "Scottish Terrier", 15, "Cookie");
var beatrice = new ShowDog("Beatrice", "Pomeranian", 5, "Hamilton");
fido.bark();
fluffy.bark();
spot.bark();
scotty.bark();
beatrice.bark();
scotty.gait("Walk");
beatrice.groom();
```

We've brought all the ShowDog code together here. Add this to the file with your Dog code to test it.

We've added some test code below.

Create some dogs and some show dogs.

Put them through their paces and make sure they're all doing the right thing.

JavaScript console

```
Fido says Woof!
Fluffy says Woof!
Spot says Yip!
Scotty says Yip!
Beatrice says Yip!
Walking
Groom
```

there are no Dumb Questions

Q: When we made the dog instance we used for the show dog prototype, we called the Dog constructor with no arguments. Why?

A: Because all we need from that dog instance is the fact that it inherits from the dog prototype. That dog instance isn't a specific dog (like Fido or Fluffy); it's simply a generic dog instance that inherits from the dog prototype.

Also, all the dogs that inherit from the show dog prototype define their own name, breed, and weight. So even if that dog instance did have values for those properties, we'd never see them because the show dog instances will always override them.

Q: So what happens to those properties in the dog instance we use for the show dog prototype?

A: They never get assigned values, so they are all undefined.

Q: If we never set the ShowDog's prototype property to a dog instance, what happens?

A: Your show dogs will work fine, but they won't inherit any behavior from the dog prototype. That means they won't be able to bark, run, or wag, nor will they have the "Canine" species property. Give it a try yourself. Comment out the line of code where we set ShowDog.prototype to new Dog() and then try making Scotty bark. What happens?

Q: Could I create an object literal and use that as the prototype?

A: Yes. You can use any object as the prototype for ShowDog. Of course, if you do that, your show dogs won't inherit anything from the dog prototype. They'll inherit the properties and methods you put in your object literal instead.

Q: I accidentally put the line of code to assign ShowDog.prototype to the instance of dog below where I created my scotty instance, and my code didn't work. Why?

A: Because when you create scotty (an instance of ShowDog), it gets the prototype that's assigned to ShowDog.prototype at the time when you create it. So if you don't assign the dog instance object to the prototype until after you create scotty, then scotty will have a different object as its prototype (the object you get by default with the ShowDog constructor). And that object doesn't have any of the Dog prototype's properties. You should assign the show dog prototype first thing after you create the constructor, but before you add anything to the prototype, or create any instances of ShowDog.

Q: If I change a property in the dog prototype, like changing species from "Canine" to "Feline", will that affect the show dogs I've created?

A: Yes, anything you change in the prototype will affect any instances that inherit from that prototype in the chain, no matter how many links you have in your chain.

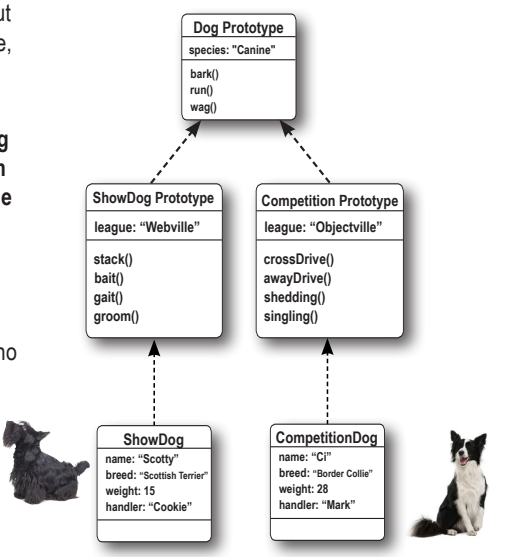
Q: Is there a limit to how long my prototype chains can be?

A: Theoretically, no, but in practice, maybe. The longer your prototype chain, the more work it is to resolve a method or property. That said, runtime systems are often quite good at optimizing these lookups.

In general, you're not going to need designs that require that many levels of inheritance. If you do, you'll probably want to take another look at your design.

Q: What if I have another category of dogs, like competition dogs. Can I create a competition dog prototype that inherits from the same dog prototype as the show dog prototype does?

A: Yes, you can. You'll need to create a separate dog instance to act as your competition dog prototype, but once you've done that you'll be good to go. Just follow the same steps we used here to create the show dog prototype.

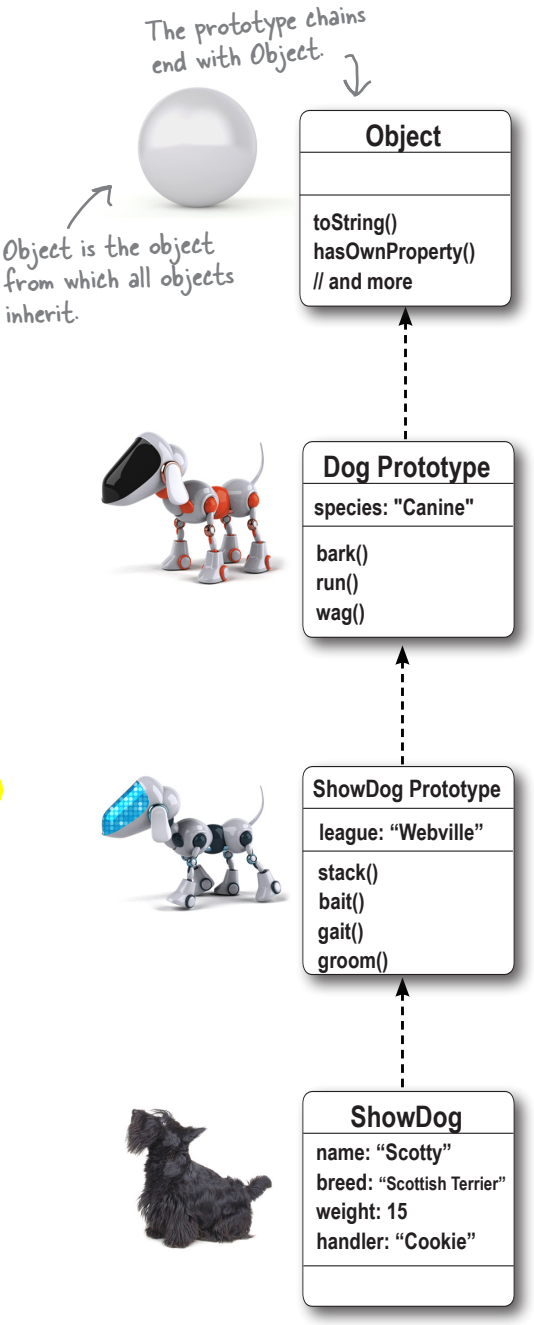


The chain doesn't end at dog

You've already seen a couple of prototype chains—we have the original dog prototype that our dog objects inherit from, and we have the more specialized show dog instances that inherit first from the show dog prototype, and the dog prototype.

But in both cases, is dog the end of the chain? Actually it isn't, because dog has its own prototype, Object.

In fact, every prototype chain you ever create will end in Object. That's because the default prototype for any instance you create (assuming you don't change it) is Object.



What is Object?

Think of Object like the primordial object. It's the object that all objects initially inherit from. And Object implements a few key methods that are a core part of the JavaScript object system. Many of these you won't use on a daily basis, but there are some methods you'll see commonly used.

One of those you've already seen in this chapter: `hasOwnProperty`, which is inherited by every object (again, because every object ultimately inherits from Object). Remember, `hasOwnProperty` is the method we used earlier to determine if a property is in an object instance or in one of its prototypes.

Another method inherited from Object is the `toString` method, which is commonly overridden by instances. This method returns a String representation of any object. We'll see in a bit how we can override this method to provide a more accurate description of our own objects.

Object as a prototype

So whether you realized it or not, every object you've ever created has had a prototype, and it's been Object. You can set an object's prototype to another kind of object, like we did with the show dog prototype, but ultimately, all prototype chains eventually lead to Object.

Using inheritance to your advantage... by overriding built-in behavior

If you're inheriting from a built-in object you can override methods in those objects. One common example is the `toString` method of Object. All objects inherit from Object, so all objects can use the `toString` method to get a simple string representation of any object. For instance, you might use it with `console.log` to display your object in the console:

```
function Robot(name, year, owner) {
    this.name = name;
    this.year = year;
    this.owner = owner;
}

var toy = new Robot("Toy", 2013, "Avary");

console.log(toy.toString());
```

JavaScript console

```
[Object object]
```

The toString method we're inheriting from Object doesn't do a very good job.

As you can see, the `toString` method doesn't do a very good job of converting the toy robot into a string. So we can override the `toString` method and write one that creates a string specifically for Robot objects:

```
function Robot(name, year, owner) {
    // same code here
}

Robot.prototype.toString = function() {
    return this.name + " Robot belonging to " + this.owner;
};

var toy = new Robot("Toy", 2013, "Avary");

console.log(toy.toString());
```

JavaScript console

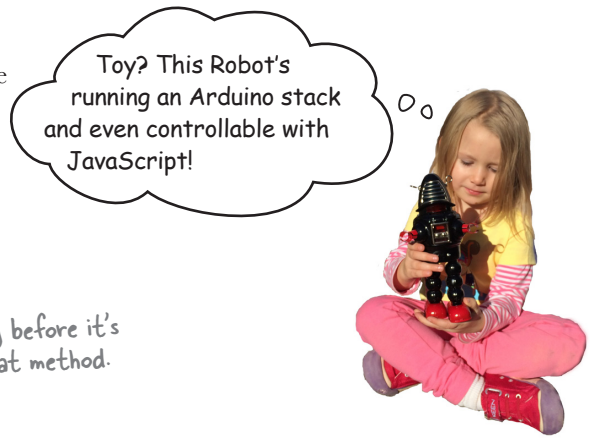
```
Toy Robot belonging to Avary
```

Much better! Now we're using our own toString method.

Notice that the `toString` method can be invoked even if you're not calling it directly yourself. For instance, if you use the + operator to concatenate a string and an object, JavaScript will use the `toString` method to convert your object to a string before concatenating it with the other string.

```
console.log("Robot is: " + toy);
```

The toy object will get converted to a string using toString before it's concatenated. If toy has overridden toString, it will use that method.



DANGER ZONE

Once you start overriding properties and methods, it's easy to get a little carried away. It's especially important to be careful when overriding properties and methods in built-in objects, because you don't want to change the behavior of other code that might rely on these properties to do certain things.

So if you're thinking of overriding properties in Object, read this Safety Guide first. Otherwise, you might end up blowing up your code in unexpected ways. (Translation: you'll have bugs that are really hard to track down.)

DO NOT OVERRIDE

Here are the properties in Object you don't want to override:

constructor — The constructor property points to the constructor function connected to the prototype.

hasOwnProperty — You know what the hasOwnProperty method does.

isPrototypeOf — isPrototypeOf is a method you can use to find out if an object is a prototype of another object.

propertyIsEnumerable — The propertyIsEnumerable method checks to see if a property can be accessed by iterating through all the properties of an object.

OKAY TO OVERRIDE

Here are the properties in Object that you can override now that you know your way around prototypes, and know how to override safely:

toString

toLocaleString — toLocaleString is a method, like toString, that converts an object to a string. This method is designed to be overridden to provide a localized string (say, for your country/language) about an object.

valueOf — valueOf is another method designed to be overridden. By default it just gives you the object you call it on. But you can override that to return another value instead if you want.

Using inheritance to your advantage... by extending a built-in object

You already know that by adding methods to a prototype, you can add new functionality to all instances of that prototype. This applies not only to your own objects, but also to built-in objects.

Take the String object for instance—you've used String methods like `substring` in your code, but what if you want to add your own method so that any instance of String could make use of it? We can use the same technique of extending objects through the prototype on Strings too.

Let's say we want to extend the String prototype with a method, `cliche`, that returns true if the string contains a known cliché. Here's how we'd do that:

Remember that while we usually think of strings as primitive types, they also have an object form. JavaScript takes care of converting a string to an object whenever necessary.

Here we're adding a method, cliche, to the String prototype.

```
String.prototype.cliche = function() {
    var cliche = ["lock and load","touch base", "open the kimono"];

    for (var i = 0; i < cliche.length; i++) {
        var index = this.indexOf(cliche[i]);
        if (index >= 0) {
            return true;
        }
    }
    return false;
};
```

We define offending phrases to look for.

And then we use the String's indexOf function to see if the string matches any of the clichés. If it does we immediately return true.

Note that **this** is the string on which we call the method cliche.

Now let's write some code to test the method:

To test let's create some sentences, including a couple that use clichés.

```
var sentences = ["I'll send my car around to pick you up.",
                 "Let's touch base in the morning and see where we are",
                 "We don't want to open the kimono, we just want to inform them."];

for (var i = 0; i < sentences.length; i++) {
    var phrase = sentences[i];
    if (phrase.cliche()) {
        console.log("CLICHE ALERT: " + phrase);
    }
}
```

Each sentence is a string, so we can call its cliche method.

Notice that we're not creating a string using the String constructor and new. JavaScript is converting each string to a String object behind the scenes for us, when we call the cliche method.

If true is returned, we know we have a cliché in the string.

Test driving the cliché machine

Get the code into a HTML file, open your browser and load it up. Check your console and you should see this output:

Works great. If only we could convince Corporate America to install this code!

JavaScript console

```
CLICHE ALERT: Let's touch base in the morning and see where we are
CLICHE ALERT: We don't want to open the kimono, we just want to inform them.
```

Watch it!

Be careful when you extend built-in objects like String with your own methods.

Make sure the name you choose for your method doesn't conflict with an existing method in the object. And if you link to other code, be aware of other custom extensions that code may have (and again, watch for name clashes). And finally, some built-in objects aren't designed to be extended (like Array). So do your homework before you start adding methods to built-in objects.

Exercise

Your turn. Write a method, palindrome, that returns true if a string reads the same forwards and backwards. (Just one word, don't worry about palindrome phrases.) Add the method to the String.prototype and test. Check your answer at the end of the chapter.

Grand Unified Theory of ~~Everything~~ JavaScript

Congratulations. You've taken on the task of learning an entirely new programming language (maybe your first language) and you've done it. Assuming you've made it this far, you now know more JavaScript than pretty much everyone.

We're using the logic that about 5.9 billion people don't know JavaScript at all, and so those who do are pretty much a rounding error, which means you know more JavaScript than just about anyone.

More seriously, if you've made it this far in the book, you are well on your way to becoming a JavaScript expert. Now all you need is more experience designing and coding web applications (or any kind of JavaScript application for that matter).

Better living through objects

When you're learning a complex topic like JavaScript, it's hard to see the forest for the trees. But, once you understand most of JavaScript, it's easier to step back and check out the forest.

When you're learning JavaScript, you learn about pieces of it at a time: you learn about primitives (that can, at any moment, be used like an object), arrays (which kinda act like objects at times), functions (which, oddly, have properties and methods like objects), constructors (which feel like part function, part object) and well… objects themselves. It all seems rather complex.

Well, with the knowledge you have now, you can sit back, relax, take a cleansing breath, and meditate on the mantra "everything is an object."

Because you see, everything *is* an object—oh, sure we have a few primitives, like booleans, numbers and strings, but we already know that we can treat those as objects anytime we need to. We have some built-in types too, like Date, Math and RegEx, but those are just objects too. Even arrays are objects, and as you saw, the only reason they look different is because JavaScript provides some nice "syntactic sugar" we can use to make creating and accessing objects easier. And of course we have objects themselves, with the simplicity of object literals and the power of the prototypal object system.

But what about functions? Are they really objects? Let's find out:

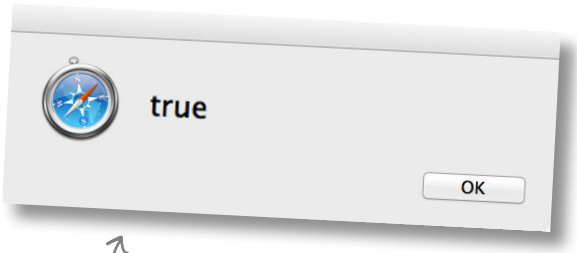
```
function meditate() {
    console.log("Everything is an object...");
}
alert(meditate instanceof Object);
```

So it's true: functions are just objects. But, really, this shouldn't be a big surprise at this point. After all we can assign functions to variables (like objects), pass them as arguments (like objects), return them from functions (like objects), and we've even seen they have properties, like this one:

```
Dog.constructor
```

Remember this is a function.

And this is a property.



It's true! Functions are objects too.

And there's nothing stopping you from adding your own properties to a function should that come in handy. And, by the way, just to bring it all full circle, have you considered that a method is just a property in an object that is set to an anonymous function expression?

Putting it all together

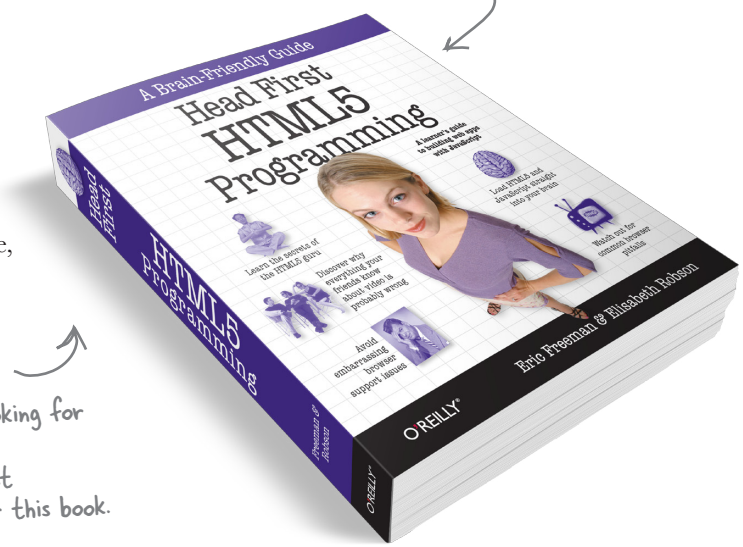
A lot of JavaScript's power and flexibility comes from the interplay between how we use functions and objects, and the fact that we can treat them as first class values. If you think about the powerful programming concepts we've studied—constructors, closures, creating objects with behavior that we can reuse and extend, parameterizing the behavior of functions, and so on—all these techniques have relied on your understanding of advanced objects and functions.

Well, now you're in a position to take this all even further…

What's next?

Now that you've got all the fundamentals down, it's time to take it all further. Now you're ready to really put your experience to use with the browser and its programming interfaces. You can do that by picking up *Head First HTML5 Programming*, which will take you through how to add geolocation, canvas drawing capabilities, local storage, web workers and more into your applications. But before you put this book down, be sure to read the appendix for a great list of other topics to explore.

Be sure to visit http://wickedlysmart.com/javascript for follow-up materials for this book and, as your next mission, should you accept it...



This is a rapidly evolving topic, so before you go looking for Head First HTML5 Programming, hit http://wickedlysmart.com/javascript for our latest recommendations and any updates and revisions for this book.

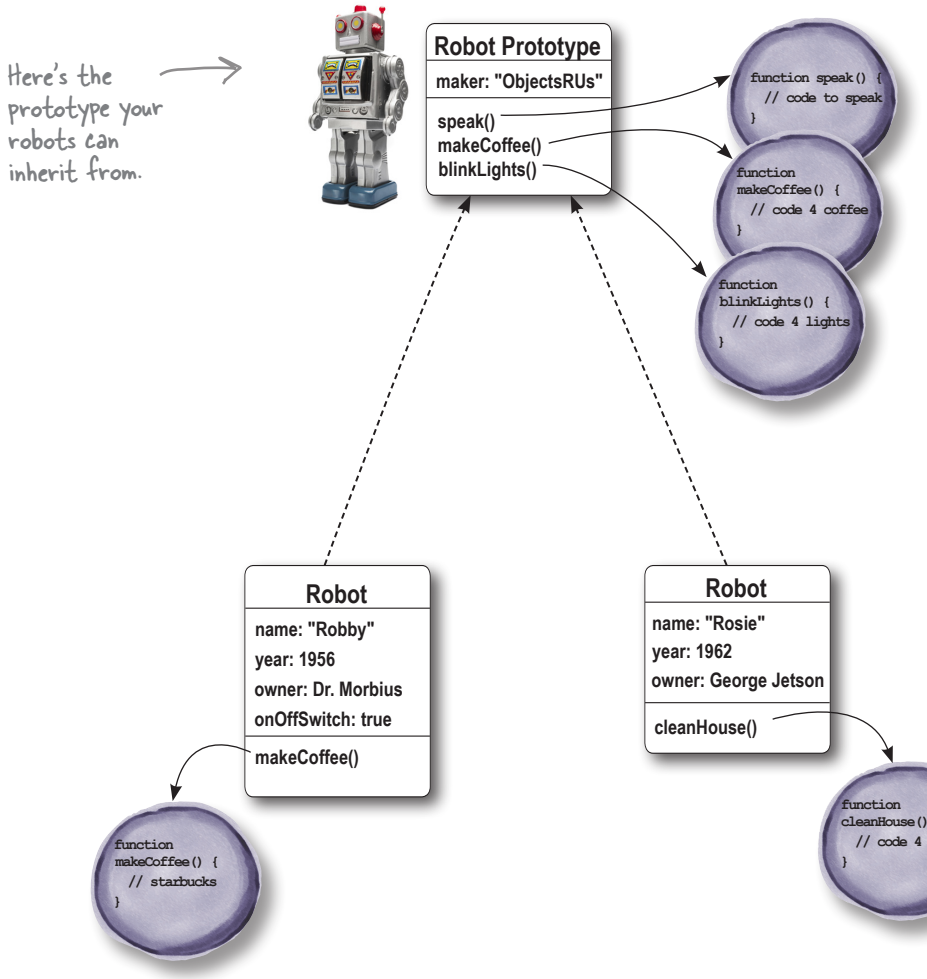
BULLET POINTS

- JavaScript's object system uses **prototypal inheritance**.
- When you create an instance of an object from a constructor, the instance has its own customized properties and a copy of the methods in the constructor.
- If you add properties to a constructor's prototype, all instances created from that constructor **inherit** those properties.
- Putting properties in a prototype can reduce runtime code duplication in objects.
- To **override** properties in the prototype, simply add the property to an instance.
- A constructor function comes with a default **prototype** that you can access with the function's prototype property.
- You can assign your own object to the prototype property of a constructor function.
- If you use your own prototype object, make sure you set the constructor function correctly to the constructor property for consistency.
- If you add properties to a prototype after you've created instances that inherit from it, all the instances will immediately inherit the new properties.
- Use the **hasOwnProperty** method on an instance to find out if a property is defined in the instance.
- The method **call** can be used to invoke a function and specify the object to be used as **this** in the body of the function.
- **Object** is the object that all prototypes and instances ultimately inherit from.
- Object has properties and methods that all objects inherit, like toString and hasOwnProperty.
- You can override or add properties to built-in objects like Object and String, but take care when doing so as your changes can have far-ranging effects.
- In JavaScript, almost everything is an object, including functions, arrays, many built-in objects, and all the custom objects you make yourself.

Code Magnets Solution

We had an object diagram on the fridge, and then someone came and messed it up. Can you help put it back together? To reassemble it, we need two instances of the robot prototype. One is Robby, created in 1956, owned by Dr. Morbius, has an on/off switch and runs to Starbucks for coffee. We've also got Rosie, created in 1962, who cleans house and is owned by George Jetson. Good luck (oh, and there might be some extra magnets below)!

Here's our solution:



Exercise Solution

Remember our object diagram for the Robby and Rosie robots? We're going to implement that now. We've already written a Robot constructor for you along with some test code. Your job is to set up the robot prototype and to implement the two robots. Make sure you run them through the test code. Here's our solution.

```
function Robot(name, year, owner) {
    this.name = name;
    this.year = year;
    this.owner = owner;
}
Robot.prototype.maker = "ObjectsRUs";
Robot.prototype.speak = function() {
    alert("Warning warning!!");
};
Robot.prototype.makeCoffee = function() {
    alert("Making coffee");
};
Robot.prototype.blinkLights = function() {
    alert("Blink blink!");
};
var robby = new Robot("Robby", 1956, "Dr. Morbius");
var rosie = new Robot("Rosie", 1962, "George Jetson");
robby.onOffSwitch = true;
robby.makeCoffee = function() {
    alert("Fetching a coffee from Starbucks.");
};
rosie.cleanHouse = function() {
    alert("Cleaning! Spic and Span soon...");
};
console.log(robby.name + " was made by " + robby.maker +
            " in " + robby.year + " and is owned by " + robby.owner);
robby.makeCoffee();
robby.blinkLights();
console.log(rosie.name + " was made by " + rosie.maker +
            " in " + rosie.year + " and is owned by " + rosie.owner);
rosie.cleanHouse();
```

Here's the basic Robot constructor.

Here we're setting up the prototype with a maker property...

...and three methods that are shared by all robots.

We create our robots, Robby and Rosie here.

Here, we're adding a custom property to Robby, as well as a custom method for making coffee (by going to Starbucks).

And Rosie also gets a custom method to clean the house (why do the girl robots have to clean?)

Here's our output (plus some alerts we're not showing).

JavaScript console

```
Robby was made by ObjectsRUs in 1956
and is owned by Dr. Morbius
Rosie was made by ObjectsRUs in 1962
and is owned by George Jetson
```

Robby and Rosie are being used in a Robot game. You'll find the code for them below. In this game, whenever a player reaches level 42, a new robot capability is unlocked: the laser beam capability. Finish the code below so that at level 42 both Robby and Rosie get their laser beams. Here's our solution.

```
function Game() {
    this.level = 0;
}

Game.prototype.play = function() {
    // player plays game here
    this.level++;
    console.log("Welcome to level " + this.level);
    this.unlock();
}

Game.prototype.unlock = function() {
    if (this.level === 42) {
        Robot.prototype.deployLaser = function () {
            console.log(this.name +  " is blasting you with laser beams.");
        }
    }
}

function Robot(name, year, owner) {
    this.name = name;
    this.year = year;
    this.owner = owner;
}

var game = new Game();
var robby = new Robot("Robby", 1956, "Dr. Morbius");
var rosie = new Robot("Rosie", 1962, "George Jetson");

while (game.level < 42) {
     game.play();
}

robby.deployLaser();
rosie.deployLaser();
```

We call unlock each time we play the game but no power is unlocked until the level reaches 42.

Here's the trick to this game: when you reach level 42, a new method is added to the prototype. That means all robots inherit the ability to deploy lasers!

JavaScript console

```
Welcome to level 1
Welcome to level 2
Welcome to level 3
 ...
Welcome to level 41
Welcome to level 42
Rosie is blasting you with
laser beams.
```

A sample of our output. When you finish your code, give it a play and see which robot wins and gets to blast its laser beams!

We've added a new capability to our robots, Robby and Rosie: they can now report when they have an error through the reportError method. Trace the code below, paying particular attention to where this method gets its error information, and to whether it's coming from the prototype of the robot instance.

Here's our solution.

```
function Robot(name, year, owner) {
    this.name = name;
    this.year = year;
    this.owner = owner;
}

Robot.prototype.maker = "ObjectsRUs";
Robot.prototype.errorMessage = "All systems go.";
Robot.prototype.reportError = function() {
    console.log(this.name + " says " + this.errorMessage);
};
Robot.prototype.spillWater = function() {
    this.errorMessage = "I appear to have a short circuit!";
};

var robby = new Robot("Robby", 1956, "Dr. Morbius");
var rosie = new Robot("Rosie", 1962, "George Jetson");

rosie.reportError();
robby.reportError();
robby.spillWater();
rosie.reportError();
robby.reportError();

console.log(robby.hasOwnProperty("errorMessage"));
console.log(rosie.hasOwnProperty("errorMessage"));
```

The reportError method only uses the value of errorMessage, so it doesn't override the property.

The spillWater method assigns a new value to this.errorMessage, which will override the property in the prototype in any robot that calls this method.

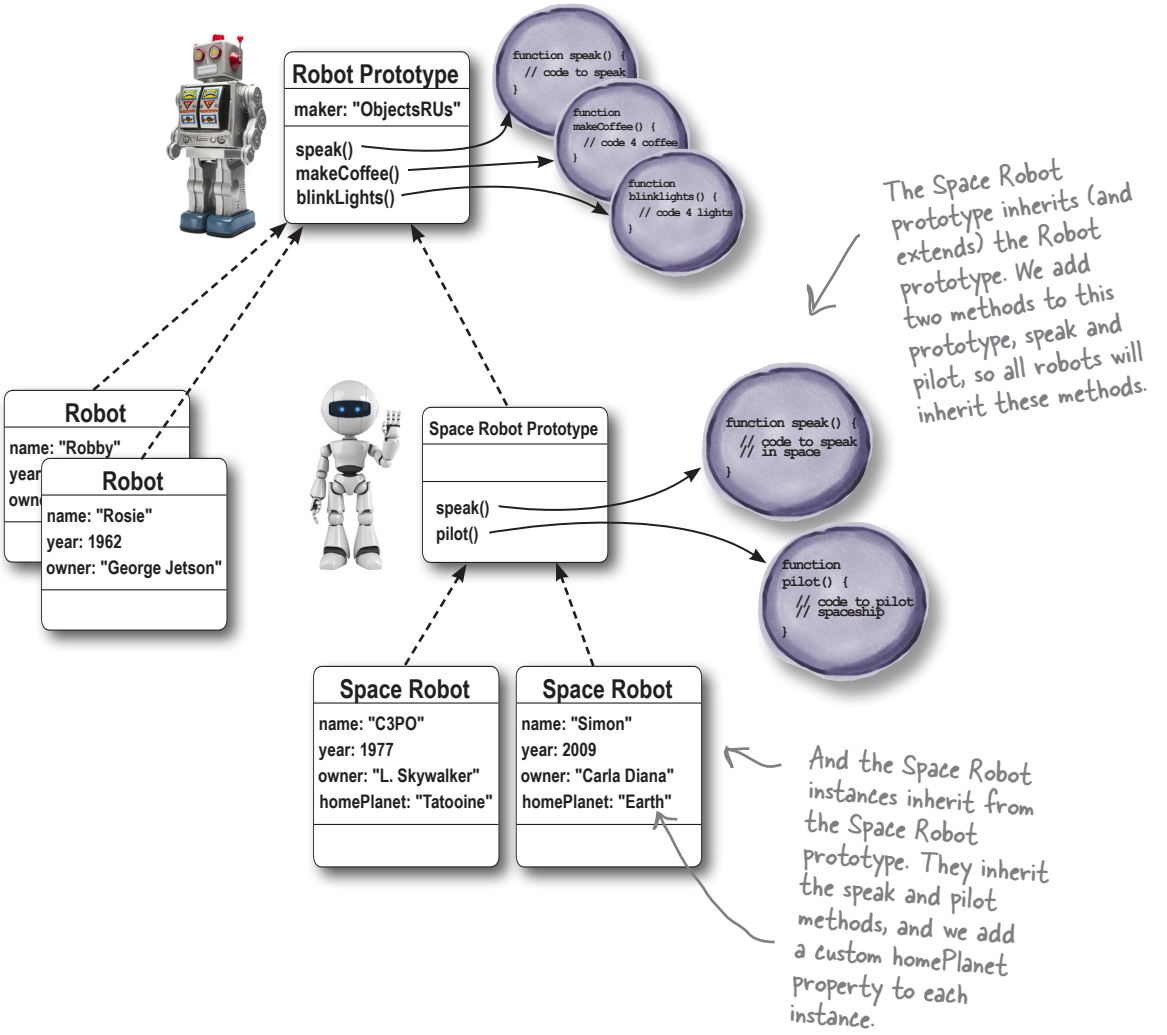
We call the spillWater method on Robby, so Robby gets his own errorMessage property, which overrides the property in the prototype.

```
true
false
```

But we never call spillWater on Rosie, so she inherits the property in the prototype.

Code Magnets Solution

We had another object diagram on the fridge, and then someone came and messed it up. Again!! Can you help put it back together? To reassemble it we need a new line of Space Robots that inherit properties from Robots. These new Space Robots override the Robot's speaking functionality, and extend Robots with piloting functionality and a new property, homePlanet. Here's our solution.



Your turn. Add a SpaceRobot line of robots to the ObjectsRUs line of robots. These robots should of course be able to do everything that robots can do, plus some extra behavior for space robots. We've started the code below, so finish it up and then test it. Here's our solution.

```
function SpaceRobot(name, year, owner, homePlanet) {
    this.name =  name;
    this.year = year;
    this.owner = owner;
    this.homePlanet = homePlanet;
}
```

The SpaceRobot constructor is similar to the Robot constructor, except we have an extra homePlanet property for the SpaceRobot instances.

```
SpaceRobot.prototype = new Robot();
```

We want the SpaceRobot prototype to inherit from the Robot prototype, so we assign a Robot instance to the SpaceRobot constructor's prototype property.

```
SpaceRobot.prototype.speak = function() {
    alert(this.name + " says Sir, If I may venture an opinion...");
};

SpaceRobot.prototype.pilot = function() {
    alert(this.name + " says Thrusters? Are they important?");
};
```

These two methods are added to the prototype.

```
var c3po = new SpaceRobot("C3PO", 1977, "Luke Skywalker", "Tatooine");
c3po.speak();
c3po.pilot();
console.log(c3po.name + " was made by " + c3po.maker);

var simon = new SpaceRobot("Simon", 2009, "Carla Diana", "Earth");
simon.makeCoffee();
simon.blinkLights();
simon.speak();
```

Here's our output (plus some alerts we're not showing).

JavaScript console

```
C3PO was made by ObjectsRUs
```

Exercise Solution

Your turn. Write a method, palindrome, that returns true if a string reads the same forward and backward. Add the method to the String.prototype and test. Here's our solution (for one word palindromes only).

```
String.prototype.palindrome = function() {
    var len = this.length-1;
    for (var i = 0; i <= len; i++) {
        if (this.charAt(i) !== this.charAt(len-i)) {
            return false;
        }
        if (i === (len-i)) {
            return true;
        }
    }
    return true;
};

var phrases = ["eve", "kayak", "mom", "wow", "Not a palindrome"];

for (var i = 0; i < phrases.length; i++) {
    var phrase = phrases[i];
    if (phrase.palindrome()) {
        console.log("'" + phrase + "' is a palindrome");
    } else {
        console.log("'" + phrase + "' is NOT a palindrome");
    }
}
```

First we get the length of the string.

Then we iterate over each character in the string, and test to see if the character at i is the same as the character at len–i (i.e., the character at the other end).

If they're not equal we return false because we don't have a palindrome.

If we get to where i is in the middle of the string, or we get to the end of the loop, we return true because we've got a palindrome.

Here are some words to test.

We just iterate through each word in the array and call the palindrome method on it. If we get back true, then we have a palindrome.

Super Advanced Solution

```
String.prototype.palindrome = function() {
    var r = this.split("").reverse().join("");
    return (r === this.valueOf());
}
```

Here, we first split the string into an array of letters, with each letter being one item in the array. We then reverse the array and join all the letters back up into a string. If the original string's value equals the new string, we've got a palindrome. Note, we have to use valueOf here, because this is an object, not a string primitive like r, so if we don't, we'd be comparing a string to an object, and they wouldn't be equal even if this is a palindrome.

Congratulations!

You made it to the end.

Of course, there's still an appendix.

And the index.

And the colophon.

And then there's the website...

There's no escape, really.

Appendix: leftovers

The top ten topics (we didn't cover)

We've covered a lot of ground, and you're almost finished with this book. We'll miss you, but before we let you go, we wouldn't feel right about sending you out into the world without a little more preparation. We can't possibly fit everything you'll need to know into this relatively small chapter. Actually, we *did* originally include everything you need to know about JavaScript Programming (not already covered by the other chapters), by reducing the type point size to .00004. It all fit, but nobody could read it. So we threw most of it away, and kept the best bits for this Top Ten appendix.
This really *is* the end of the book. Except for the index, of course (a must-read!).

#1 jQuery

jQuery is a JavaScript library that is aimed at reducing and simplifying much of the JavaScript code and syntax that is needed to work with the DOM and add visual effects to your pages. jQuery is an enormously popular library that is widely used and expandable through its plug-in model.

Now, there's nothing you can do in jQuery that you can't do with JavaScript (as we said, jQuery is just a JavaScript library); however, it does have the power to reduce the amount of code you need to write.

jQuery's popularity speaks for itself, although it can take some getting used to if you are new to it. Let's check out a few things you can do in jQuery and we encourage you to take a closer look if you think it might be for you.

A working knowledge of jQuery is a good skill these days on the job front and for understanding others' code.

For starters, remember all the `window.onload` functions we wrote in this book? Like:

```
window.onload = function() {
    alert("the page is loaded!");
}
```

Here's the same thing using jQuery:

```
$(document).ready(function() {
    alert("the page is loaded!");
});
```

Just like our version, when the document is ready, invoke my function.

Or you can shorten this even more, to:

```
$(function() {
    alert("the page is loaded!");
});
```

This is cool, but as you can see it takes a little getting used to at first. No worries, it becomes second-nature fast.

So what about getting elements from the DOM? That's where jQuery shines. Let's say you have an `<a>` element in your page with an id of "buynow" and you want to assign a click handler to the click event on that element (like we've done a few times in this book). Here's how you do that:

So what's going on here? First we're setting up a function that is called when the page is loaded.

```
$(function() {
   $("#buynow").click(function() {
       alert("I want to buy now!");
   });
});
```

Next we're grabbing the element with a "buynow" id (notice jQuery uses CSS syntax for selecting elements).

And then we're calling a jQuery method, click, on the result to set the onclick handler.

That's really just the beginning; we can just as easily set the click handler on every <a> element in the page:

```
$(function() {
   $("a").click(function() {
       alert("I want to buy now!");
   });
});
```

To do that, all we need to do is use the tag name.

Compare this to the code you'd write to do this if we were using JavaScript without jQuery.

Or, we can do things that are much more complex:

```
$(function() {
   $("#playlist > li").addClass("favorite");
});
```

Like find all the <li> elements that are children of the element with an id of playlist.

And then add the class "favorite" to all the elements.

Actually this is jQuery just getting warmed up; jQuery can do things much more sophisticated than this.

There's a whole 'nother side of jQuery that allows you to do interesting interface transformations on your elements, like this:

```
$(function() {
    $("#specialoffer").click(function() {
        $(this).fadeOut(800, function() {
            $(this).fadeIn(400);
        });
    });
});
```

This makes the element with an id of specialoffer fade out and then fade back in at different rates.

As you can see, there's a lot you can do with jQuery, and we haven't even talked about how we can use jQuery to talk to web services, or all the plug-ins that work with jQuery. If you're interested, the best thing you can do is point your browser to http://jquery.com/ and check out the tutorials and documentation there.

And, check out Head First jQuery too!

#2 Doing more with the DOM

We've touched on some of the things you can do with the DOM in this book, but there's a lot more to learn. The objects that represent the document in your page—that is, the `document` object, and the various element objects—are chock full of properties and methods you can use to interact with and manipulate your page.

You already know how to use `document.getElementById` and `document.getElementsByTagName` to get elements from the page. The `document` object has these other methods you can use to get elements, too:

`document.getElementsByClassName` — Pass this method the name of a class, and you'll get back all elements that have that class, as a NodeList.

`document.getElementsByName` — This method retrieves elements that have a name attribute with a value that matches the name you pass it.

`document.querySelector` — This method takes a selector (just like a CSS selector) and returns the first element that matches.

`document.querySelectorAll` — This method also takes a selector, but returns all the elements that match, as a NodeList.

Here's how you'd use `document.querySelector` to match a list item element with the class "song" that's nested in a `<ul>` element with the id "playlist":

```
var li = document.querySelector("#playlist .song");
```

This says match the element with the id playlist, and then match the first element with the class song.

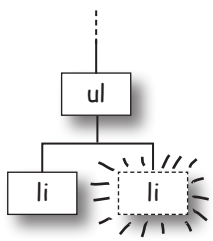
Notice how this selector is just like one you'd write in CSS?

What if you want to add new elements to your page from your code? You can use a combination of `document` object methods and element methods to do that, like this:

```
var newItem = document.createElement("li");
newItem.innerHTML = "Your Random Heart";
var ul = document.getElementById("playlist");
ul.appendChild(newItem);
```

First, we create a new <li> element, and set its content to a string.

Then we get the <ul> element we want to add the new <li> to (as a child element), and append the <li> to the <ul>.



There's a lot more you can do with the DOM using JavaScript. For a good introduction, check out *Head First HTML5 Programming*.

#3 The Window Object

You've heard of the DOM, but you should know there's also a BOM, or Browser Object Model. It's not really an official standard, but all browsers support it through the `window` object. You've seen the `window` object in passing when we've used the `window.onload` property, and you'll remember we can assign an event handler to this property that is triggered when the browser has fully loaded a page.

You've also seen the `window` object when we've used the `alert` and `prompt` methods, even though it might not have been obvious. The reason it wasn't obvious is that `window` is the object that acts as the global namespace. When you declare any kind of global variable or define a global function, it is stored as a property in the `window` object. So for every call we made to `alert`, we could have instead called `window.alert`, because it's the same thing.

Another place you've used the window object without knowing it is when you've used the `document` object to do things like get elements from the DOM with `document.getElementById`. The `document` object is a property of `window`, so we could write `window.document.getElementById`. But, just like with `alert`, we don't have to, because `window` is the global object, and it is the default object for all the properties and methods we use from it.

In addition to being the global object, and supplying the `onload` property and the `alert` and `prompt` methods, the `window` object supplies other interesting browser-based properties and methods. For instance, it's common to make use of the width and height of the browser window to tailor a web page experience to the size of the browser. You can access these values like this:

```
window.innerWidth
window.innerHeight
```

Use these properties to get the browser window's width and height in pixels. Note that older browsers don't always expose these properties.

Check out the W3C documentation* for more on the `window` object. Here are a few common methods and properties:

```
window.close()
```
This method closes the browser window.

```
window.setTimeout()
window.setInterval()
```
You already know these methods; they're supplied by the window object.

```
window.print()
```
Initiates printing the page to your printer.

```
window.confirm()
```
This method is similar to prompt, only it gives the user the choice of an Okay or Cancel button.

```
window.history
```
This property is an object containing the browsing history.

```
window.location
```
This property is the URL of the current page. You can also set this property to direct the browser to load a new page.

* http://www.w3.org/html/wg/drafts/html/CR/browsers.html#the-window-object

#4 Arguments

An object named `arguments` is available in every function when that function is called. You won't ever see this object in the parameter list, but it is available nevertheless every time a function is called, in the variable `arguments`.

The `arguments` object contains every argument passed to your function, and it can be accessed in an array-like manner. You can use `arguments` to create a function that accepts a variable number of arguments, or create a function that does different things depending on the number of arguments passed to it. Let's see how `arguments` works with this code:

We're not going to define any formal parameters for now. We'll just use the arguments object.

Like an array, arguments has a length property.

```
function printArgs() {
    for (var i = 0; i < arguments.length; i++) {
        console.log(arguments[i]);
    }
}

printArgs("one", 2, 1+2, "four");
```

And we can access each argument using array notation.

Here we call printArgs with four arguments.

```
JavaScript console
one
2
3
four
```

While `arguments` looks just like an array, it is not actually an array; it's an object. It has a `length` property, and you can iterate over it and access items in it using bracket notation, but that's where the similarity with an array ends. Also, note that you can use both parameters and the `arguments` object in the same function. Let's write one more piece of code to see how a function with a variable number of arguments might be written:

We can define parameters like normal. In this case, using a parameter helps indicate how to use this function.

```
function emote(kind) {
    if (kind === "silence") {
        console.log("Player sits in silence");
    } else if (kind === "says") {
        console.log("Player says: '" + arguments[1] + "'");
    }
}

emote("silence");
emote("says", "Stand back!");
```

If the first argument is "silence" then we don't expect another. If the first argument is "says", then we use arguments[1] to get the second argument.

```
JavaScript console
Player sits in silence
Player says: 'Stand back!'
```

#5 Handling exceptions

JavaScript is a fairly forgiving language, but now and then things go wrong—wrong enough that the browser can't continue executing your code. When that happens, your page stops working, and if you look in the console you're likely to see an error. Let's take a look at an example of some code that causes an error. Start by creating a simple HTML page with a single element in the body:

```
<div id="message"></div>
```

Now, add the following JavaScript:

```
window.onload = function() {
    var message = document.getElementById("messge");
    message.innerHTML = "Here's the message!";
};
```

We're making an error in this code. Can you see what we did wrong?

Load the page in your browser, make sure the console is open, and you'll get an error. Can you see what went wrong? We mistyped the id of the `<div>` element, so when your code tries to retrieve that `<div>` element it fails, and the variable `message` is null. And you can't access the `innerHTML` property of null.

JavaScript console

```
Uncaught TypeError: Cannot set
property 'innerHTML' of null
```

When you get an error that causes your code to stop executing like this one does, it's called an exception. JavaScript has a mechanism, called try/catch, that you can use to watch for exceptions and catch them when they happen. The idea is that if you can catch one of these exceptions, rather than your code just stopping, you can take an alternative action (try something else, offer the user a different experience, etc.).

Try/catch

The way you use try/catch is like this: you put the code you want to try in the try block, and then you write a catch block that contains code that will be executed in case anything goes wrong with the code in the try block. The catch keyword is followed by parentheses that contain a variable name (that acts a lot like a function parameter). If something goes wrong and an exception is caught, the variable will be assigned to a value related to the exception, often an Error object. Here's how you use a try/catch statement:

```
window.onload = function() {
    try {
        var message = document.getElementById("messge");
        message.innerHTML = "Here's the message!";
    } catch (error) {
        console.log("Error! " + error.message);
    }
};
```

We moved our code into a try block.

Here, we're trying to set the innerHTML property of message (which is null) to a string.

If the code in the try block causes an exception, then this line of code is executed. All we're doing is displaying the message property of the error object in the console. Then execution continues with the line following the try/catch.

Depending on the error, you could do something much smarter here.

#6 Adding event handlers with addEventListener

In this book, we used object properties to assign event handlers to events. For instance, when we wanted to handle the load event, we assigned an event handler to the `window.onload` property. And when we wanted to handle a button click, we assigned an event handler to that button's `onclick` property.

This is a convenient way of assigning event handlers. But sometimes, you might need a more general way of assigning event handlers. For instance, if you want to assign multiple handlers for one event type, you can't do that if you use a property like `onload`. But you can with a method named `addEventListener`:

We call addEventListener on window to register a handler for the load event.

And we pass it three arguments: the name of the event, "load", as a string...

...a reference to the handler function for the event...

...and a flag indicating if we want to bubble the event up (we'll explain bubble in a moment).

```
window.addEventListener("load", init, false);
function init() {
   // page has loaded
}
```

So the init function is called when the load event happens.

You can assign a second load event handler to window simply by calling `addEventListener` again, passing a different event handler function reference as the second argument. This is handy if you want to split your initialization code into two separate functions, but remember—you won't know which handler will be called first, so keep that in mind as you're designing your code.

The third argument to `addEventListener` determines if the event is "bubbled up" to parent elements. This doesn't make a difference for the load event (because the window object is at the top level), but if you have, say, a `<span>` element nested inside a `<div>` element, and you click on the `<span>` but want the `<div>` to receive the event, then you can set bubble to true instead of false.

It's totally fine to mix and match using the event properties, like `onload`, with `addEventListener`. Also, if you add an event handler with `addEventListener`, you can remove it later with `removeEventListener`, like this:

We're using the onload property to assign the load event handler for window.

And using addEventListener to assign the event handler for the 's click event.

When you click the , we remove the event handler from the div with removeEventListener.

```
window.onload = function() {
    var div = document.getElementById("clickme");
    div.addEventListener("click", handleClick, false);
};
function handleClick(e) {
    var target = e.target;;
    alert("You clicked on " + target.id);
    target.removeEventListener("click", handleClick, false);
}
```

Event handling in IE8 and older

We've handled a few different kinds of events in this book—mouse clicks, load events, key presses, and more—and hopefully you've been using a modern browser and the code has worked for you. However, if you are writing a web page that handles events (and what web page doesn't?) and you're concerned that some of the people in your audience may be using versions of Internet Explorer (IE) that are version 8 or older, you need to be aware of an issue with event handling.

Unfortunately, IE handled events differently from other browsers until IE9. You could use properties like `onclick` and `onload` to set event handlers across all browsers, however, the way that older IE browsers handle the event object is different. In addition, if you happen to be using the standardized `addEventListener` method, IE didn't support this method until IE9 and later. Here are the main issues to be aware of:

- IE8 and older browsers do support most of the "on" properties you can use to assign event handlers.
- IE8 and older browsers use a method named `attachEvent` instead of the `addEventListener` method.
- When an event is triggered and your event handler is called, instead of passing an event object to the handler, IE8 and older store the event object in the window object.

So, if you want to be sure that your code works across all browsers, including IE8 and older browsers, then you can manage these differences like this:

```
window.onload = function() {
    var div = document.getElementById("clickme");
    if (div.addEventListener) {
        div.addEventListener("click", handleClick, false);
    } else if (div.attachEvent) {
        div.attachEvent("onclick", handleClick);
    }
};
function handleClick(e) {
    var evt = e || window.event;
    var target;
    if (evt.target) {
        target = evt.target;
    } else {
        target = evt.srcElement;
    }
    alert("You clicked on " + target.id);
}
```

IE8 supports the onload property for the load event so this is okay.

If you use the addEventListener method to add an event handler, you need to check to make sure the method exists...

...and if it doesn't, use the attachEvent method instead. Notice attachEvent doesn't have a third argument, and uses "onclick" for the event name.

If the event object is passed, then you know you're dealing with IE9+ or another browser. Otherwise, you have to get the event object from the window.

If the event object is the modern one, the element that triggered the event will be in the target property, like normal. But if this is IE8 or older, this element will be in the srcElement property.

#7 Regular Expressions

You've seen the RegExp object in passing in this book—"RegExp" stands for *regular expression*, which is, formally, a grammar for describing patterns in text. For instance, using a regular expression, you could write an expression that matches all text that starts with "t" and ends with "e" , with at least one "a" and no more than two "u"s in between.

Regular expressions can get complex fast. In fact, regular expressions can almost seem like an alien language when you first try to read them. But you can get started with simple regular expressions fairly quickly, and if you like them, check out a good reference on the topic.

The RegExp constructor

Let's take a look at a couple of regular expressions. To create a regular expression, pass a search pattern to the RegExp constructor, between two slashes, like this:

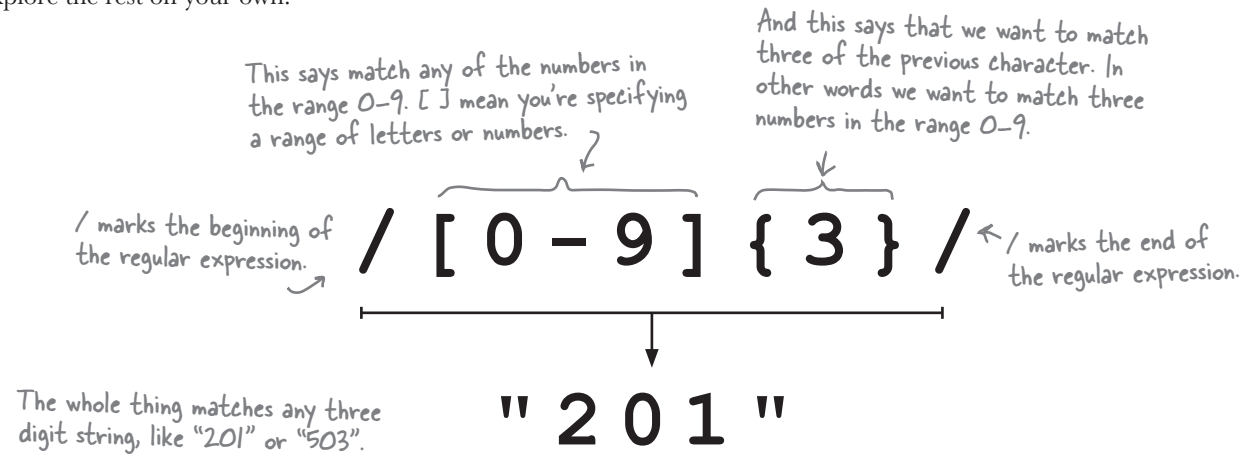
The argument to the RegExp constructor is the search pattern. How do you read these two search patterns?

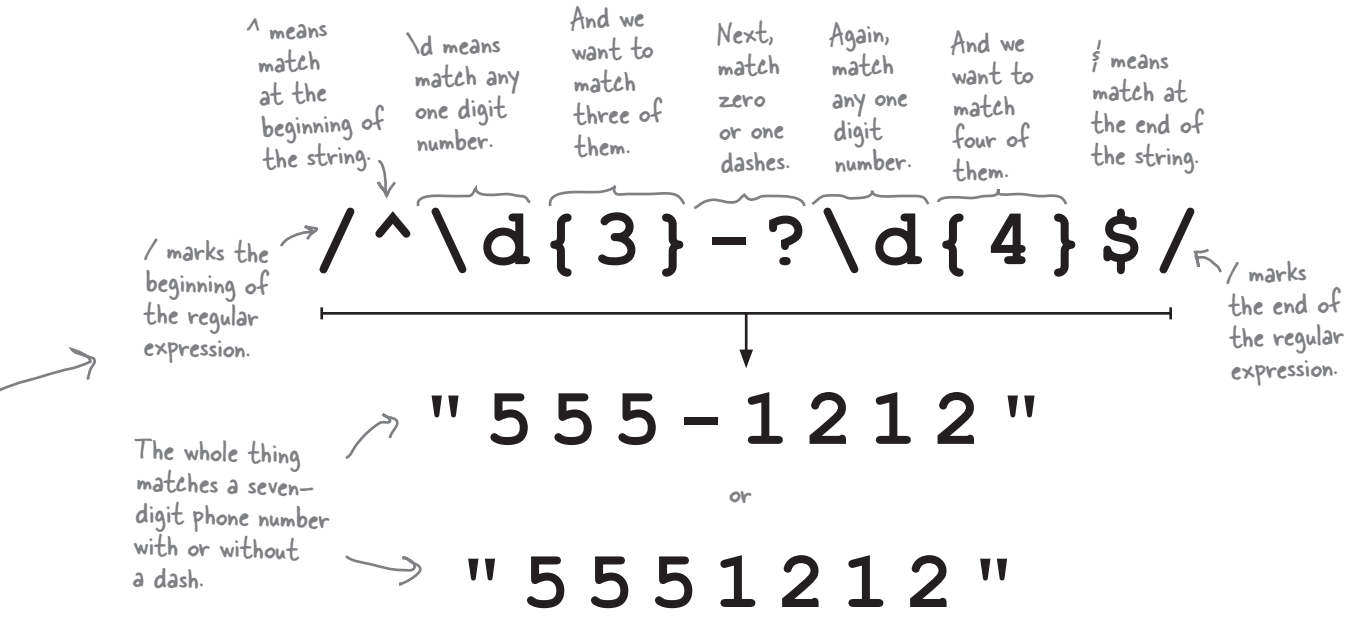
```
var areaCode = new RegExp(/[0-9]{3}/);

var phoneNumber = new RegExp(/^\d{3}-?\d{4}$/);
```

Like this...

Remember this from Chair Wars back in Chapter 7? This was Amy's winning code.

The key to understanding regular expressions is learning how to read the search patterns. These search patterns are the most complex part of regular expressions, so we'll work through the two examples here, and you'll have to explore the rest on your own.





Using a RegExp object

To use a regular expression, you first need a string to search:

```
var amyHome = "555-1212";
```

Then, you match the regular expression to the string by calling the `match` method on the string, and passing the regular expression object as an argument:

```
var result = amyHome.match(phoneNumber);
```

The value in result is ["555-1212"], because in this case, the entire string in the variable amyHome matched.

The result is an array containing any parts of the string that matched. If the result is null, then nothing in the string matched the regular expression:

```
var invalid = "5556-1212";
var result2 = invalid.match(phoneNumber);
```

The value in result2 is null because no part the string in the variable invalid matched our regular expression search pattern.

Once you've got a regular expression, like `phoneNumber`, you can just keep using it to match as many strings as you like.

#8 Recursion

When you give a function a name it allows you to do something quite interesting: call that function from within the function. We call this *recursion*, or a recursive function call.

Now why would you need such a thing? Well, some problems are inherently recursive. Here's one from mathematics: an algorithm to compute the Fibonacci number series. The Fibonacci number series is:

0, 1, 1, 2 , 3, 5, 8, 13, 21, 34, 55, 89, 144... and so on.

To compute a Fibonacci number we start by assuming:

Fibonacci of 0 is 1

Fibonacci of 1 is 1

and then to compute any other number in the series we simply add together the two previous numbers in the series. So:

Fibonacci of 2 is Fibonacci of 1 + Fibonacci of 0 = 2

Fibonacci of 3 is Fibonacci of 2 + Fibonacci of 1 = 3

Fibonacci of 4 is Fibonacci of 3 + Fibonacci of 2 = 5

and so on… The algorithm to compute Fibonacci numbers is inherently recursive because you compute the next number using the results of the previous two Fibonacci numbers.

We can make a recursive function to compute Fibonacci numbers like this: to compute the Fibonacci of the number n, we call the Fibonacci function with the argument n-1 and call the Fibonacci function with the argument n-2, and then add the results together.

Let's do that in code. We'll start by handling the cases of 0 and 1:

We start with a function that accepts n, the number in the series we're after.

```
function fibonacci(n) {
    if (n === 0) return 1;
    if (n === 1) return 1;
}
```

Then we know that if the number is either 0 or 1, we return 1. This is known as the base case of the function, because it doesn't make any recursive calls.

These are the *base cases*—that is, the cases that don't rely on previous Fibonacci numbers to compute—and it is usually good to write them first. From there you can think like this: "To compute a Fibonacci number n, I return the result of adding the Fibonacci of n-1 and the Fibonacci of n-2.

Let's do that…

```
function fibonacci(n) {
    if (n === 0) return 1;
    if (n === 1) return 1;
    return (fibonacci(n-1) + fibonacci(n-2));
}
```

Now if n isn't 0 or 1, we just need to compute the Fibonacci by adding together the Fibonacci of n–1 and n–2.

This looks a little like magic if you've never seen recursion before, but this does compute Fibonacci numbers. Let's clean the code up a little, and test it:

Same code, just written a little better.

```
function fibonacci(n) {
    if (n === 0 || n === 1) {
        return 1;
    } else {
        return (fibonacci(n-1) + fibonacci(n-2));
    }
}
```

And some test code.

```
for (var i = 0; i < 10; i++) {
    console.log("The fibonacci of " + i + " is " + fibonacci(i));
}
```

JavaScript console

```
The fibonacci of 0 is 1
The fibonacci of 1 is 1
The fibonacci of 2 is 2
The fibonacci of 3 is 3
The fibonacci of 4 is 5
The fibonacci of 5 is 8
The fibonacci of 6 is 13
The fibonacci of 7 is 21
The fibonacci of 8 is 34
The fibonacci of 9 is 55
```

Watch it!

Make sure you have a base case.

If recursive code never reaches a base case where the computation ends, it will run forever, like an infinite loop. In other words, the function will continue calling itself over and over, consuming resources until your browser can't take it anymore. So if you write recursive code and your page isn't responding, figure out how to make sure you're getting to the base case.

#9 JSON

Not only is JavaScript the programming language of the Web, it's becoming a common interchange format for storing and transmitting objects. JSON is an acronym for "JavaScript Object Notation" and is a format that allows you to represent a JavaScript object as a string—a string that can be stored and transmitted:

A JSON string.

```
var fidoString = '{ "name": "Fido", "breed": "Mixed", "weight": 38 }';
```

Notice that we're using single quotes around the JSON string. We have to use single quotes because the string contains double quotes, so JavaScript will get confused otherwise. This way, JavaScript knows this is one long string that contains other strings.

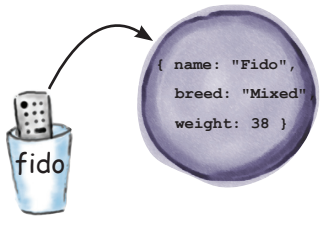
Look familiar? It should. This string looks a lot like the fido object we worked with earlier in the book...

Now, the cool thing about JSON is we can take strings like this and turn them into objects. The way we do it is with a couple of methods supplied by JavaScript `JSON` object: `JSON.parse` and `JSON.stringify`. We'll use the `parse` method to parse the `fidoString` above and turn it into a real dog (well, a JavaScript object anyway):

Notice that we're using the JSON object here. JSON is both the name of a string format and an object in JavaScript.

```
var fido = JSON.parse(fidoString);
```

We call the parse method of the JSON object, passing the string above, and we get back...



...a real JavaScript object. We store the reference to the object in the variable fido.

And you can go the other way, too. If you have an object, `fido`, and you want to turn it into a string, you just call the `JSON.stringify` method, like this:

```
var fido = {
    name: "Fido",
    breed: "Mixed",
    weight: 38
};
var fidoString = JSON.stringify(fido);
```

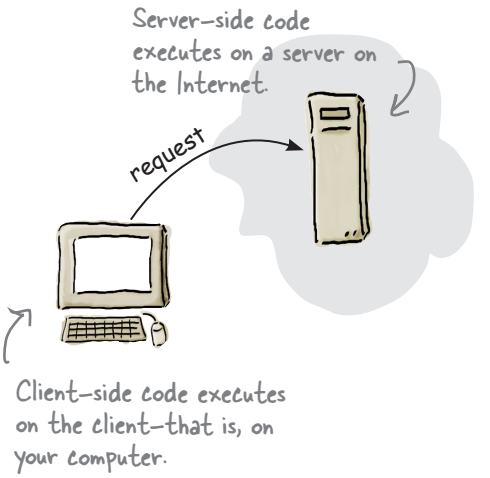
Here, we're taking a JavaScript object...

...and turning it into a string.

Note that the JSON format doesn't work with methods (so you can't include, say, a `bark` method in your JSON string), but it does work with all the primitive types, as well as objects and arrays.

#10 Server-side JavaScript

In this book we've focused on the browser and client-side programming, but there's a whole world of server-side programming where you can now use your JavaScript skills. Server-side programming is typically required for the kinds of web and cloud services you use on the Internet. If you want to create Webville Taco's new online order system, or you think the next big idea is the anti-social network, you'll need to write code that lives and runs in the cloud (on a server on the Internet).



Node.js is the JavaScript server-side technology of choice these days, and it includes its own runtime environment and set of libraries (in the same way client-side JavaScript uses the browser's libraries). And like the browser, Node.js runs JavaScript in a single-threaded model where only one thread of execution can happen at a time. This leads to a programing model similar to the browser that is based on asynchronous events and an event loop.

As an example, the method below starts up a web server listening for incoming web requests. It takes a handler that is responsible for handling those requests when they occur. Notice that the convention for setting up the event handler for incoming requests is to pass an anonymous function to the `createServer` method.

The http.createServer Node.js library method takes a handler in the form of an anonymous function as an argument.

```
http.createServer(function(request, response) {
  response.writeHead(200, {"Content-Type": "text/plain"});
  response.write("Hello World");
  response.end();
}).listen(8888);
```

The anonymous function is responsible for taking care of requests. It responds to incoming requests by sending back the string "Hello World".

Of course, there is much more to explain and to work through to understand how Node.js works. But, given your knowledge of objects and functions you are well positioned to take this on. Also, explaining Node.js requires at least an entire book of its own, but you'll also find many online tutorials, articles and demonstrations at http://nodejs.org.

Colophon

All interior layouts were designed by Eric Freeman and Elisabeth Robson.

Kathy Sierra and Bert Bates created the look & feel of the Head First series. The book was produced using Adobe InDesign CS5.5 and Adobe Photoshop CS5.5. The book was typeset using Uncle Stinky, Mister Frisky (you think we're kidding), Ann Satellite, Baskerville, Comic Sans, Myriad Pro, Skippy Sharp, Savoye LET, Jokerman LET, Courier New and Woodrow typefaces.

Interior design and production was done exclusively on Apple Macintoshes—a Mac Pro, an iMac, a Macbook Pro, and two MacBook Airs to be precise.

Writing locations were primarily Bainbridge Island, Washington; Austin, Texas; Port of Ness, Scotland; Seaside, Florida.

Sonic environment during writing included BT, Daft Punk, Muse, The Fixx, Depeche Mode, Adam & the Ants, Men without Hats, Sleep Research Lab, Dousk, Uh Huh Her, Art of Noise, deadmau5 & Kaskade, David Bowie, Cheap Trick, The Who, Blank & Jones, Chris Isaak, Roy Orbison, Elvis, John Lennon, George Harrison, Amy Macdonald, Schiller, Sia, Sigur Ros, Tom Waits, OMD, Phillip Glass, Muse, Eno, Krishna Das, Mike Oldfield, Devo, Steve Roach, Beyman Brothers, Harry and the Potters, and the soundtracks for Frozen, Harry Potter, Back to the Future and Pleasantville.

Index

Symbols

A

B

C

D

E

F

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

Z

I can't believe the book is almost over. Before you go, you really should read the index. It's great stuff. And after that you've always got the website. So I'm sure we'll see you again soon...

Don't worry, this isn't goodbye.

Nor is it the end. Now that you've got an amazingly solid foundation in JavaScript, it's time to become a master. Point your browser to `http://wickedlysmart.com/hfjs` to explore what's next!

What's next? So much more! Join us at http://wickedlysmart.com/hfjs to continue your journey.