D3 Introduction

Alec Glassford and Zach Maurer

Slides adapted from

Maneesh Agrawala

Jessica Hullman

Ludwig Schubert

Peter Washington

CS 448B: Visualization

Fall 2017

Topics

1) What is D3? Why do we use it?

2) D3 as DOM manipulation.

3) D3 as DataViz tool.

4) Running example.
   - Scales, Axes, Coordinates, Marks
   - Filtering, Updating, Interactivity

[Adapted from Mike Bostock's D3 Workshop]

What is D3?

Why do we use it?

Visualization with Web Standards

D3: "Data-Driven Documents"

Data visualization built on top of HTML, CSS, JavaScript, and SVG

Pros:

- Highly-customizable
- Developing and debugging tools
- Documentation, resources, community
- Integrates with the web!

Cons:

- Very "low-level".

What does D3 look like?

i.e. What does HTML, CSS, JS look like?

hello-world.html

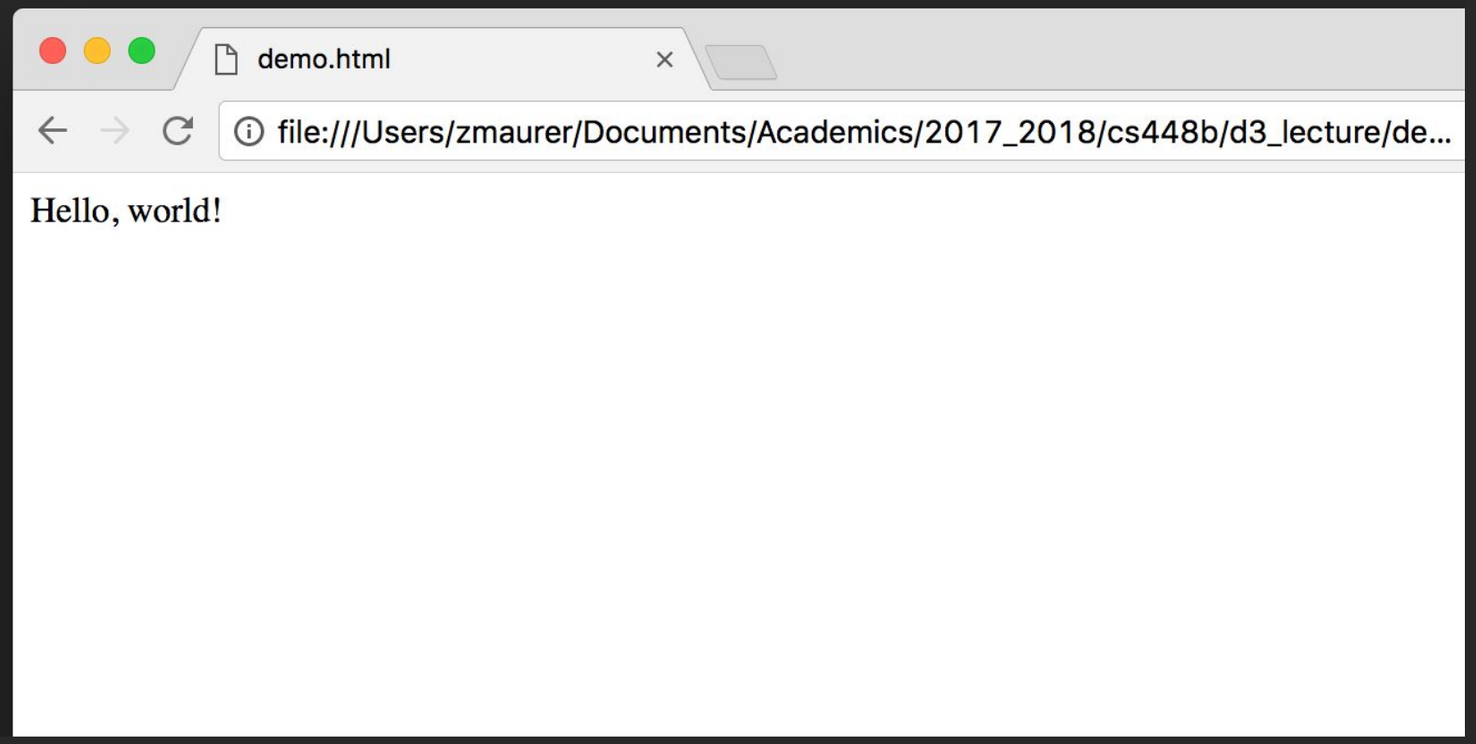
```
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8">
</head>

<!-- Your html spec here -->

</html>
```

hello-world.html

```
<!DOCTYPE html>
<html>
<head>
 <meta charset="utf-8">
</head>

<body>
 Hello, world!
</body>

</html>
```

hello-world.html

```
<!DOCTYPE html>
<html>
<head>
 <meta charset="utf-8">
</head>

<body>
 Hello, world!
</body>

</html>
```

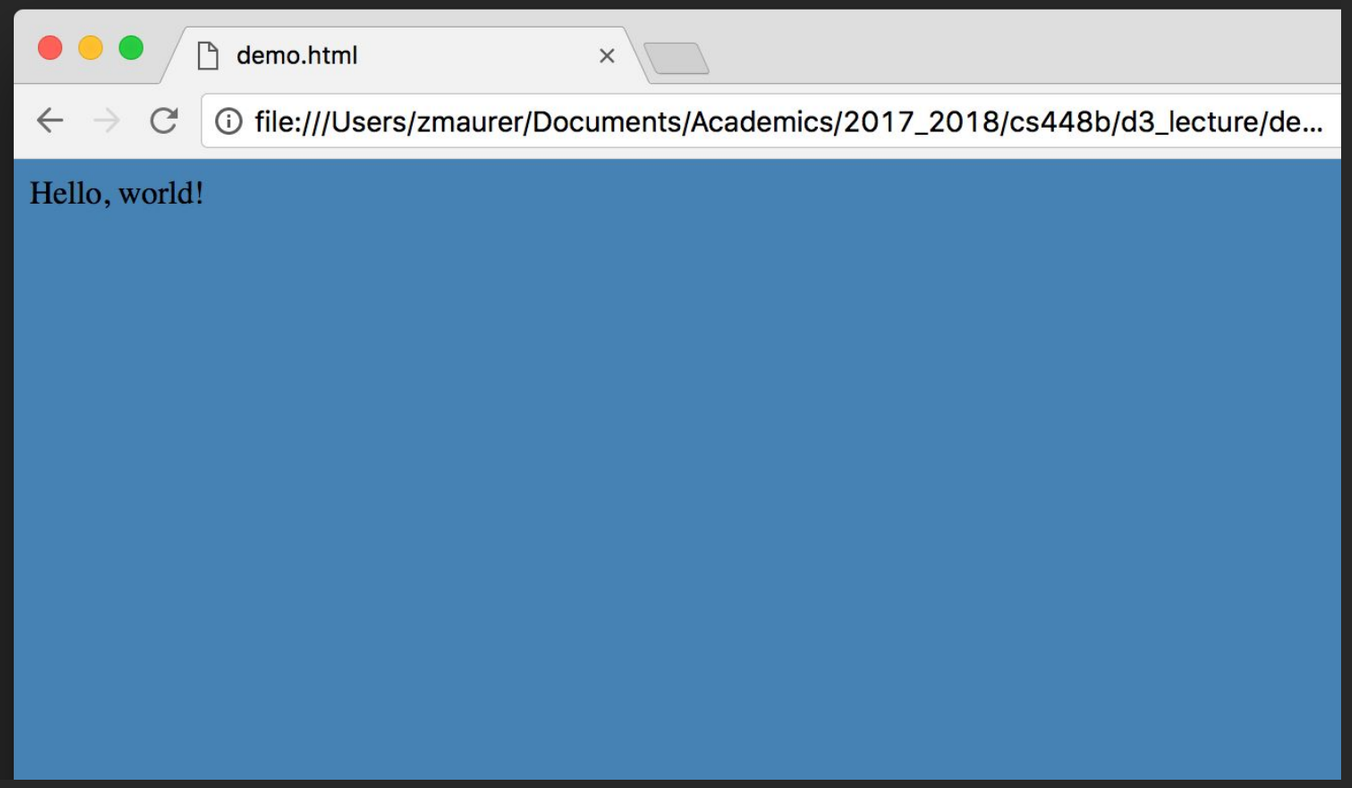


hello-css.html

```
<!DOCTYPE html>
<html>
<head>
 <meta charset="utf-8">

  <style>
   body { background: steelblue; }
  </style>

</head>

<body>
 Hello, world!
</body>

</html>
```

hello-css.html

```
<!DOCTYPE html>
<html>
<head>
 <meta charset="utf-8">

  <style>
   body { background: steelblue; }
  </style>

</head>

<body>
 Hello, world!
</body>

</html>
```

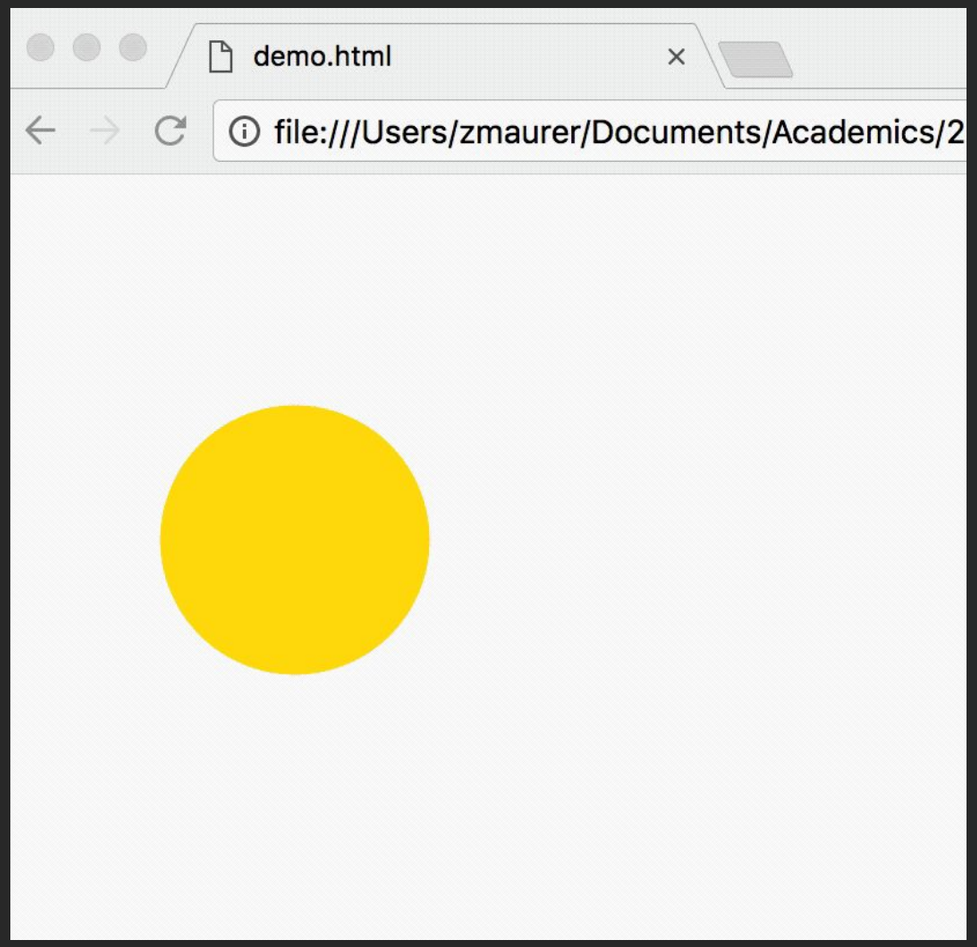


hello-svg.html

```
<!DOCTYPE html>
<html>
<head>
 <meta charset="utf-8">
 <style> /* CSS */ </style>
</head>

<body>
    <svg width="960" height="500">
      <circle cx='120' cy='150' r='60' style='fill: gold;'>
          <animate
              attributeName='r'
              from='2' to='80' begin='0' dur='3'
              repeatCount='indefinite' />
      </circle>
    </svg>
</body>
</html>
```

hello-svg.html

```
<!DOCTYPE html>
<html>
<head>
 <meta charset="utf-8">
 <style> /* CSS */ </style>
</head>

<body>
      <svg width="960" height="500">
          <circle cx='120' cy='150' r='60' style='fill: gold;'>
                <animate attributeName='r'
                      from='2' to='80' begin='0' dur='3'
                      repeatCount='indefinite' />
          </circle>
      </svg>
</body>
</html>
```

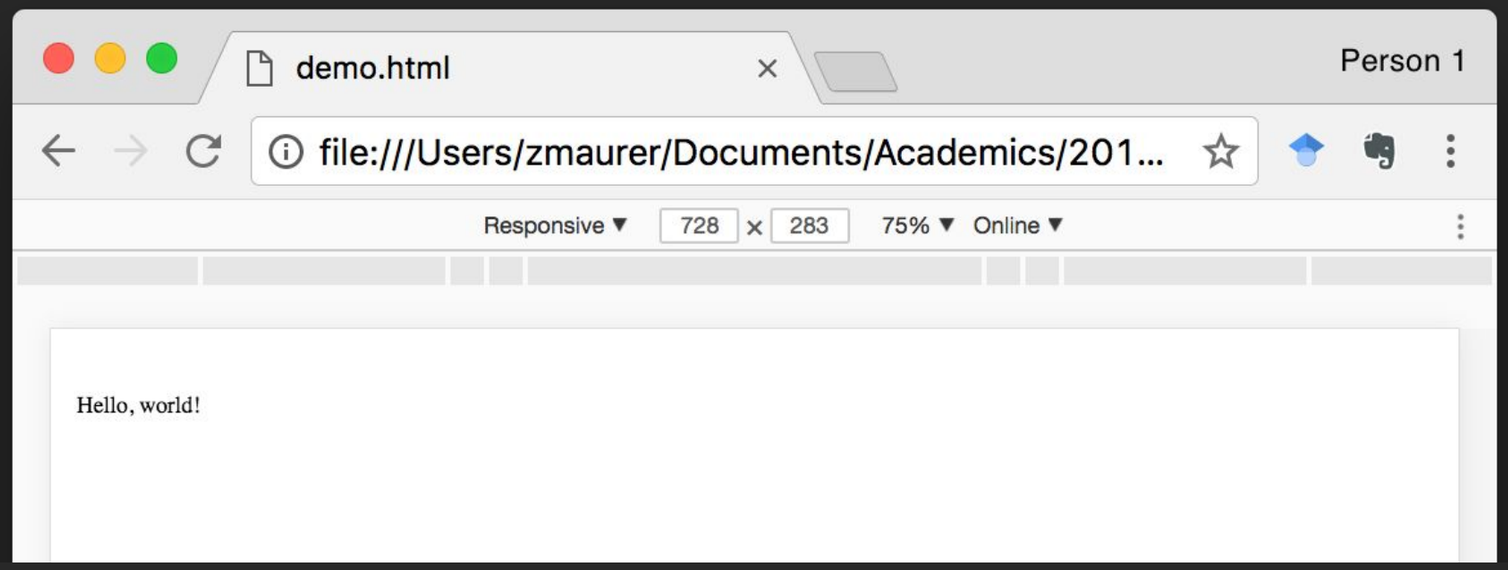


hello-javascript.html

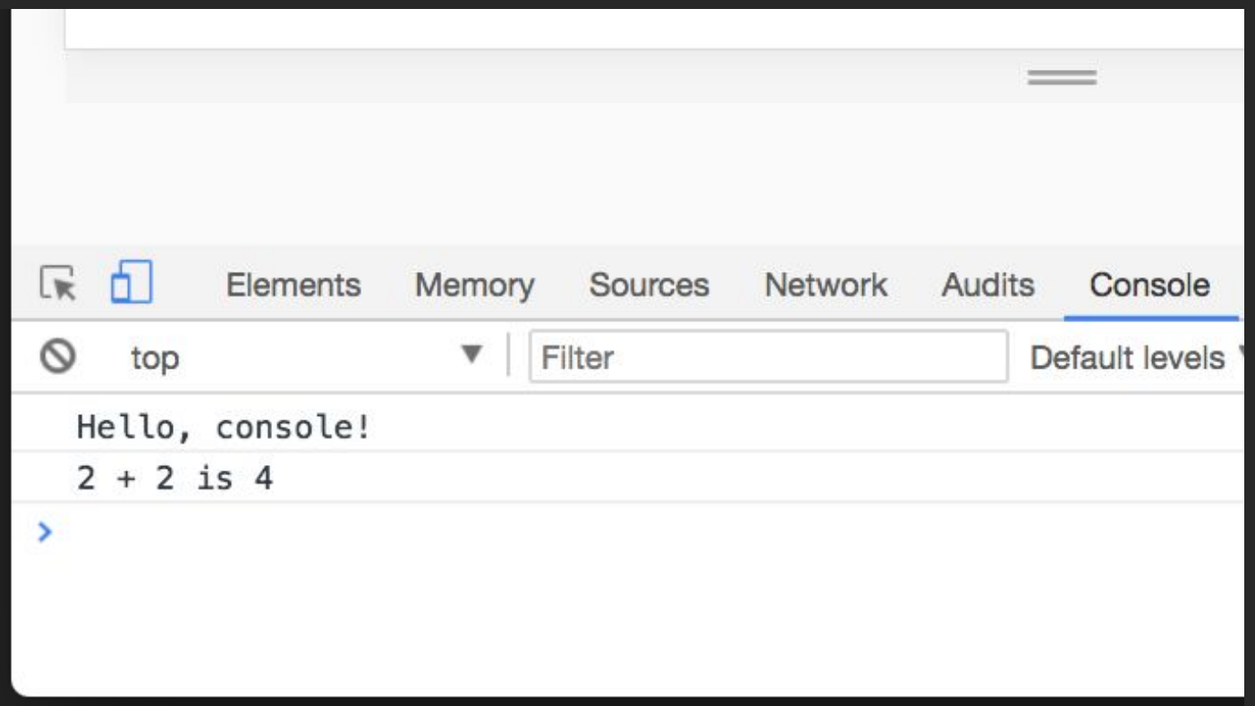
```
<!DOCTYPE html>
<html>
<head>
 <meta charset="utf-8">
 <style> /* CSS */ </style>
</head>

<body>
Hello, world!
 <script>
  console.log("Hello, world!");
   function add2(x) {
      return x + 2;
     }
  console.log("2 + 2 is " + add2(2));
 </script>
</body>
</html>
```

hello-javascript.html

```
<!DOCTYPE html>
<html>
<head>
 <meta charset="utf-8">
 <style> /* CSS */ </style>
</head>

<body>
Hello, world!
 <script>
   console.log("Hello, world!");
     function add2(x) {
          return x + 2;
        }
   console.log("2 + 2 is " + add2(2));
 </script>
</body>
</html>
```



...



hello-d3.html

```
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8">
  <style> /* CSS */ </style>
</head>

<body>
  <script src="https://d3js.org/d3.v4.min.js"></script>
  <script>

    // JavaScript code that handles the logic of adding SVG elements
    // that make up the visual building blocks of your data visualization

  </script>
</body>
</html>
```

hello-d3.html

```
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8">
  <style> /* CSS */ </style>
</head>

<body>
  <script src="https://d3js.org/d3.v4.min.js"></script>
  <script>

    // JavaScript code that handles the logic of adding SVG elements
    // that make up the visual building blocks of your data visualization

  </script>
</body>
</html>
```

DOM Manipulation

What is the DOM?

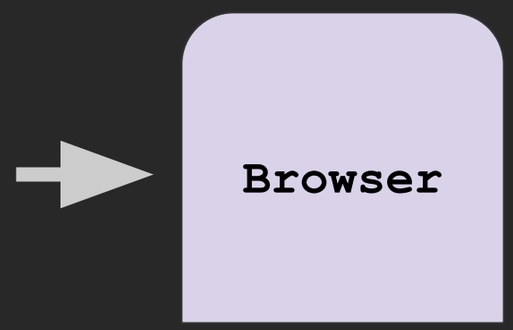
DOM: "Document Object Model"

```
<html>
   <head>
      <title></title>
   </head>
   <body>
      <h1></h1>
      <div>
         <p></p>
      </div>
   </body>
</html>
```

[Adapted from Victoria Kirst's cs193x slides.]

DOM: "Document Object Model"

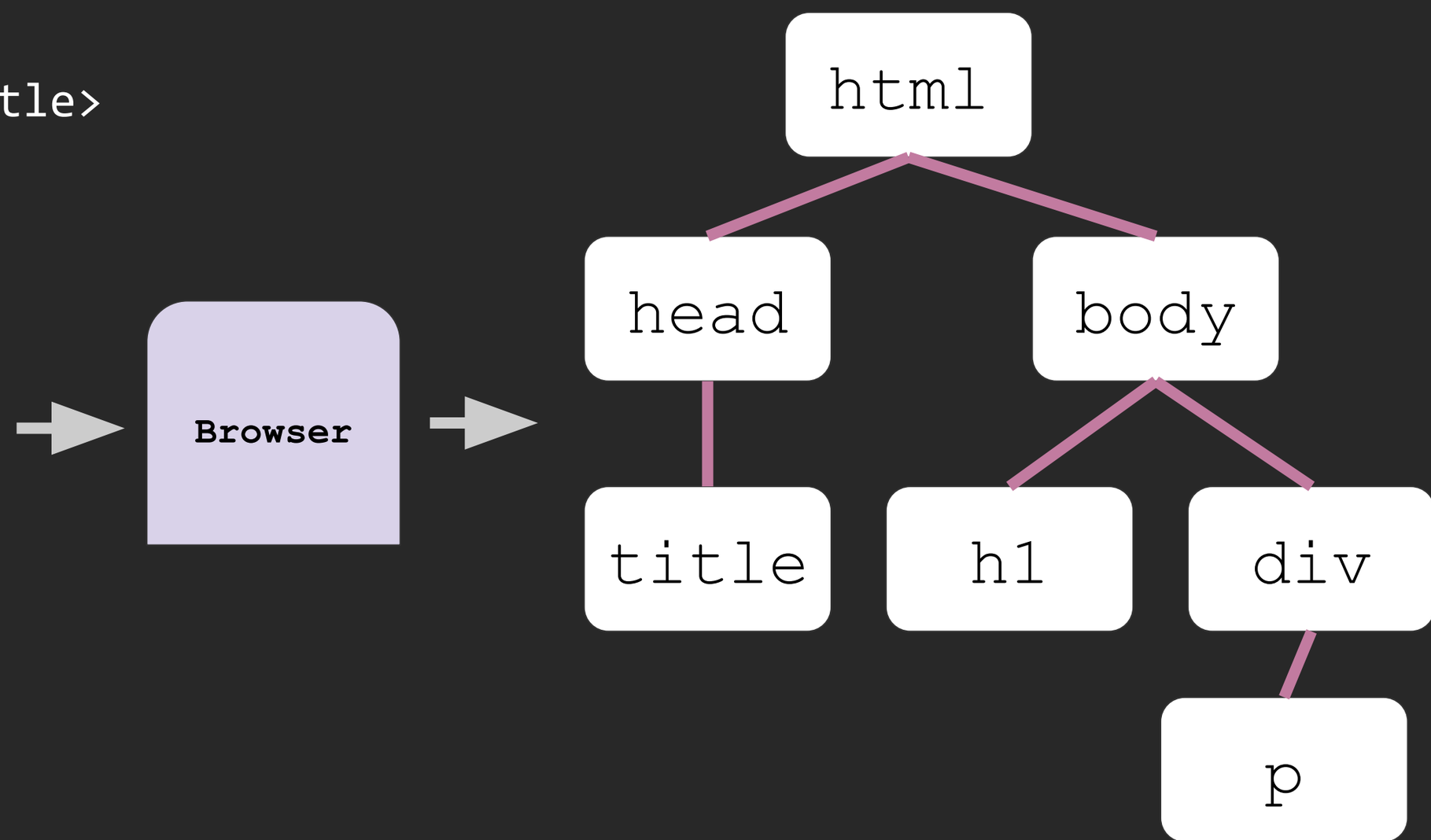
```
<html>
   <head>
      <title></title>
   </head>
   <body>
      <h1></h1>
      <div>
         <p></p>
      </div>
   </body>
</html>
```



[Adapted from Victoria Kirst's cs193x slides.]

DOM: "Document Object Model"

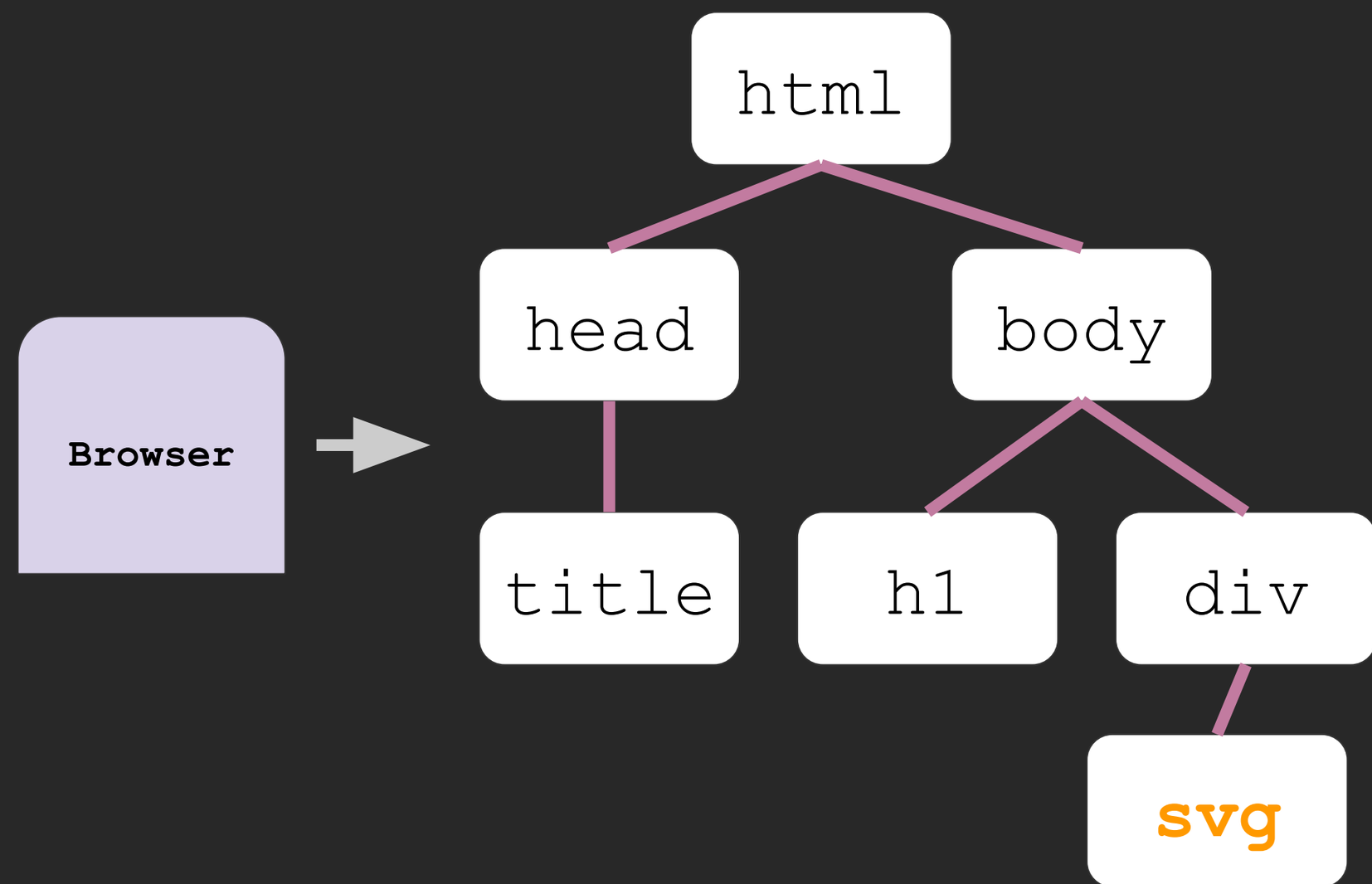
```
<html>
   <head>
      <title></title>
   </head>
   <body>
      <h1></h1>
      <div>
         <p></p>
      </div>
   </body>
</html>
```



[Adapted from Victoria Kirst's cs193x slides.]

DOM: "Document Object Model"

```
<html>
   <head>
      <title></title>
   </head>
   <body>
      <h1></h1>
      <div>
         <svg></svg>
      </div>
   </body>
</html>
```



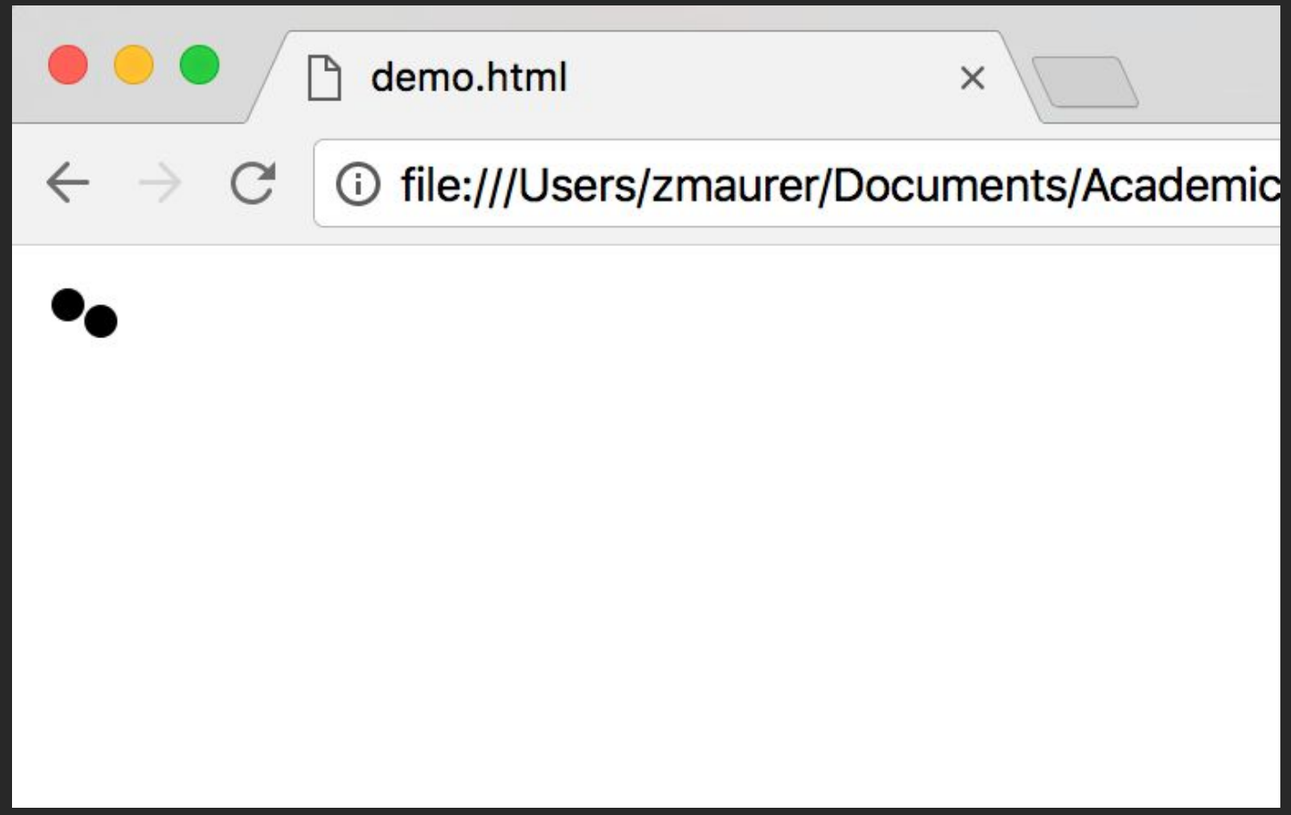
[Adapted from Victoria Kirst's cs193x slides.]

D3: Selecting & manipulating DOM

```
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```

D3: Selecting & manipulating DOM

```
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```



D3: Selecting & manipulating DOM

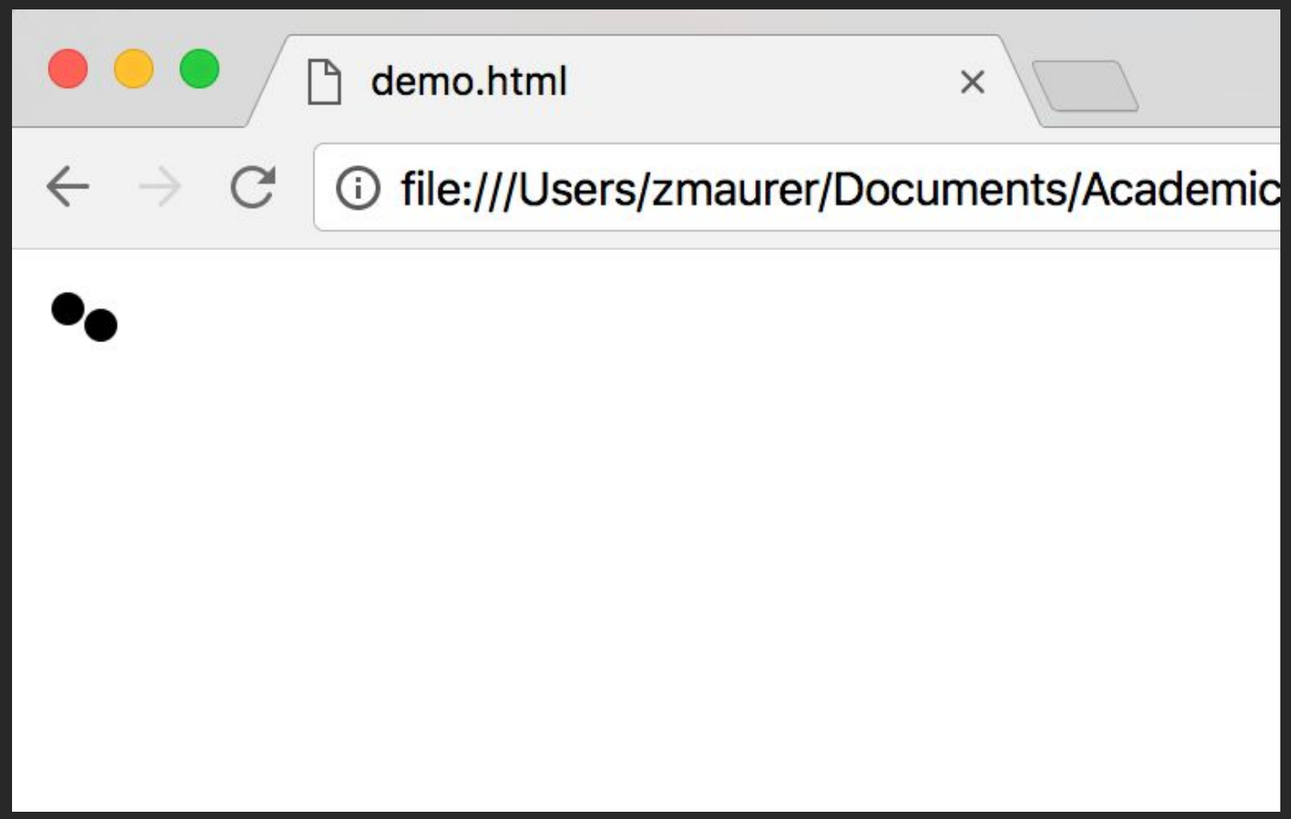
```
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```

```
<script>

// select all SVG circle elements
var circles =
      d3.selectAll("circle");

</script>
```

D3: Selecting & manipulating DOM

```
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```

```
<script>

// select all SVG circle elements
var circles =
      d3.selectAll("circle");

</script>
```



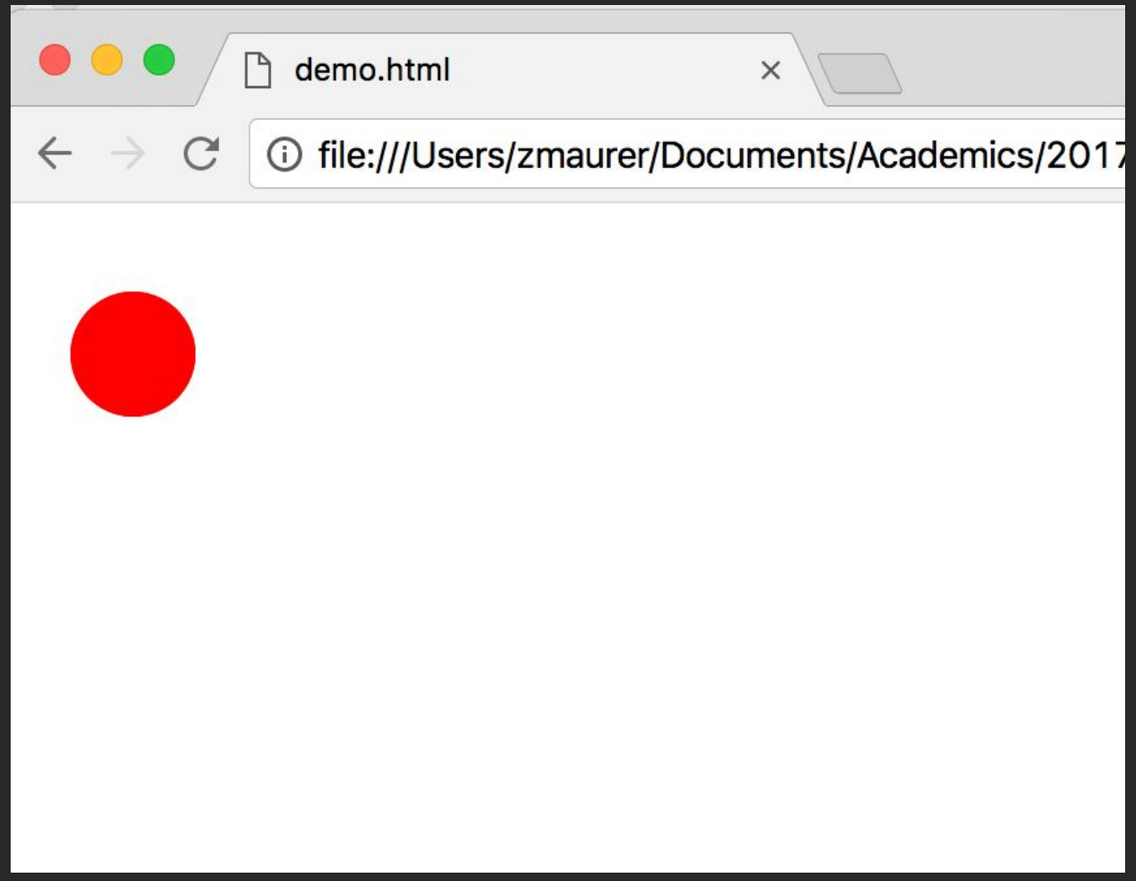
D3: Selecting & manipulating DOM

```html
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```

```script
<script>

// select all SVG circle elements
var circles =
      d3.selectAll("circle");

// set attributes and styles
circles.attr("cx", 40);
circles.attr("cy", 50);
circles.attr("r", 24);
circles.style("fill", "red");

</script>
```

D3: Selecting & manipulating DOM

```
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```




```
<script>

// select all SVG circle elements
var circles =
      d3.selectAll("circle");

// set attributes and styles
circles.attr("cx", 40);
circles.attr("cy", 50);
circles.attr("r", 24);
circles.style("fill", "red");

</script>
```

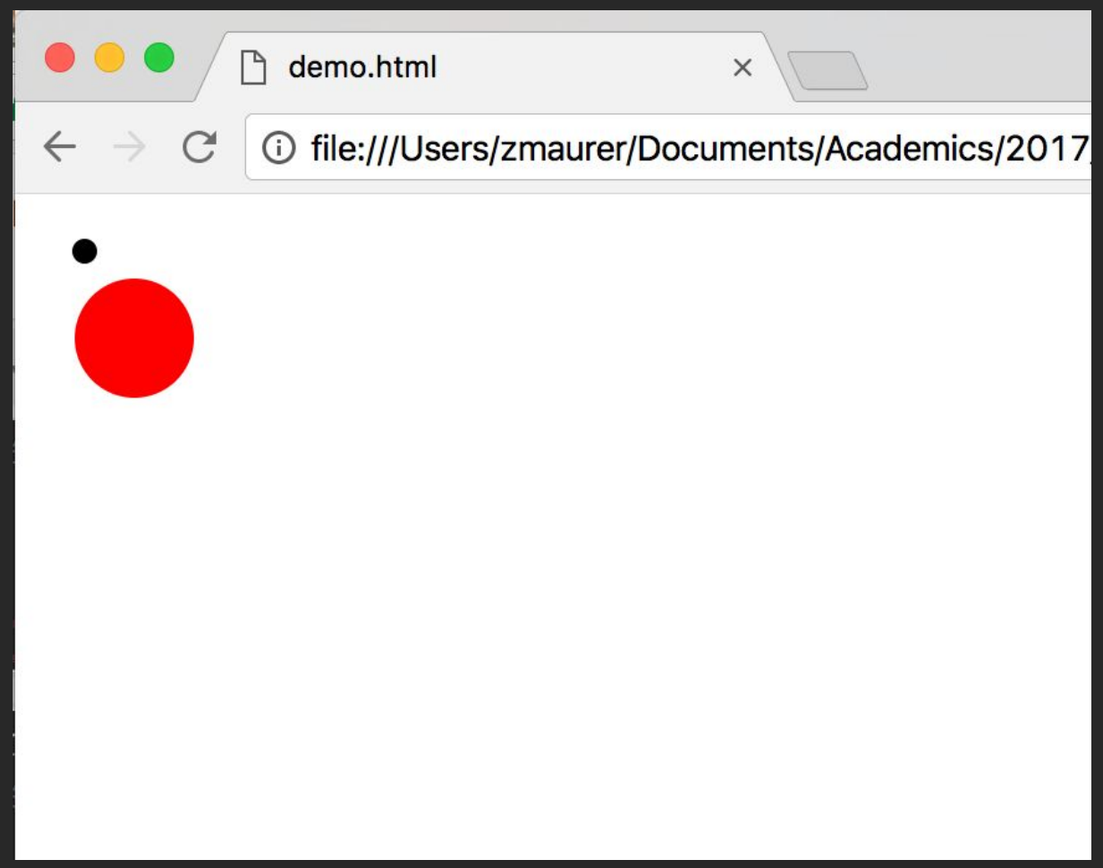
D3: Selecting & manipulating DOM

```html
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```

```script
<script>

// select all SVG circle elements
var circles = d3.select("circle");


// set attributes and styles
circles.attr("cx", 40);
circles.attr("cy", 50);
circles.attr("r", 24);
circles.style("fill", "red");

</script>
```

D3: Selecting & manipulating DOM

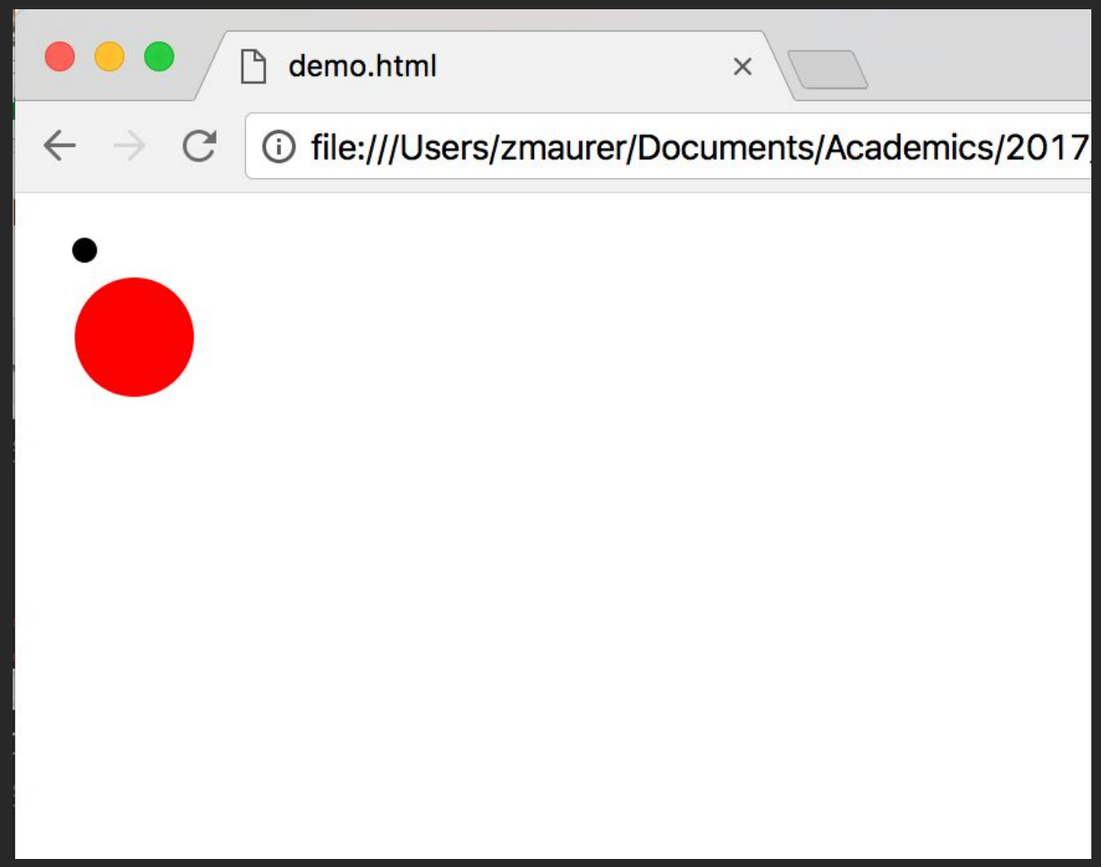
```
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```




```
<script>

// select all SVG circle elements
var circles = d3.select("circle");


// set attributes and styles
circles.attr("cx", 40);
circles.attr("cy", 50);
circles.attr("r", 24);
circles.style("fill", "red");

</script>
```

D3: Selecting & manipulating DOM

```
<html>
...
<svg width="960" height="500">
  <circle cx="10" cy="10" r="5"></circle>
  <circle cx="20" cy="15" r="5"></circle>
</svg>
```




```
<script>

// all together!!
d3.select("circle")
    .attr("cx", 40)
    .attr("cy", 50)
    .attr("r", 24)
    .style("fill", "red");

</script>
```

Where do I learn about SVG attributes and D3 functions?

SVG Attribute Reference
https://developer.mozilla.org/en-US/docs/Web/SVG/Attribute

D3 API Reference v4.0
https://github.com/d3/d3/blob/master/API.md

D3 as a DataViz tool.

Data	Selections	Mappings
Dynamic JS Object	d3.selectAll(..) .data(myData)	.enter() .append(..) .style(..) .text(..)

Data

Dynamic JS
Object

Selections

```
d3.selectAll(..)
  .data(myData)
```

Mappings

```
.enter()
  .append(..)
  .style(..)
  .text(..)
```

Data elements are bound to nodes in the DOM.

Data

Dynamic JS
Object

Selections

```
d3.selectAll(..)
  .data(myData)
```

Mappings

```
.enter()
  .append(..)
  .style(..)
  .text(..)
```

Data elements are bound to nodes in the DOM.

Bound elements are 'drawn' with SVG / HTML attributes and CSS.

Let's make a scatter plot

```
id,animal,weight,height,name
1,cat,10,3,phyllis
2,cat,3,3,oreo
3,cat,9,9,sam
4,cat,3,5,dog
5,cat,6,5,fred
6,cat,5,6,jane
7,cat,1,8,esmerelda
8,dog,9,2,garfield
9,dog,8,9,alpha
10,dog,7,7,omega
11,dog,2,3,zeta
12,dog,8,3,cupcake
```

Steps

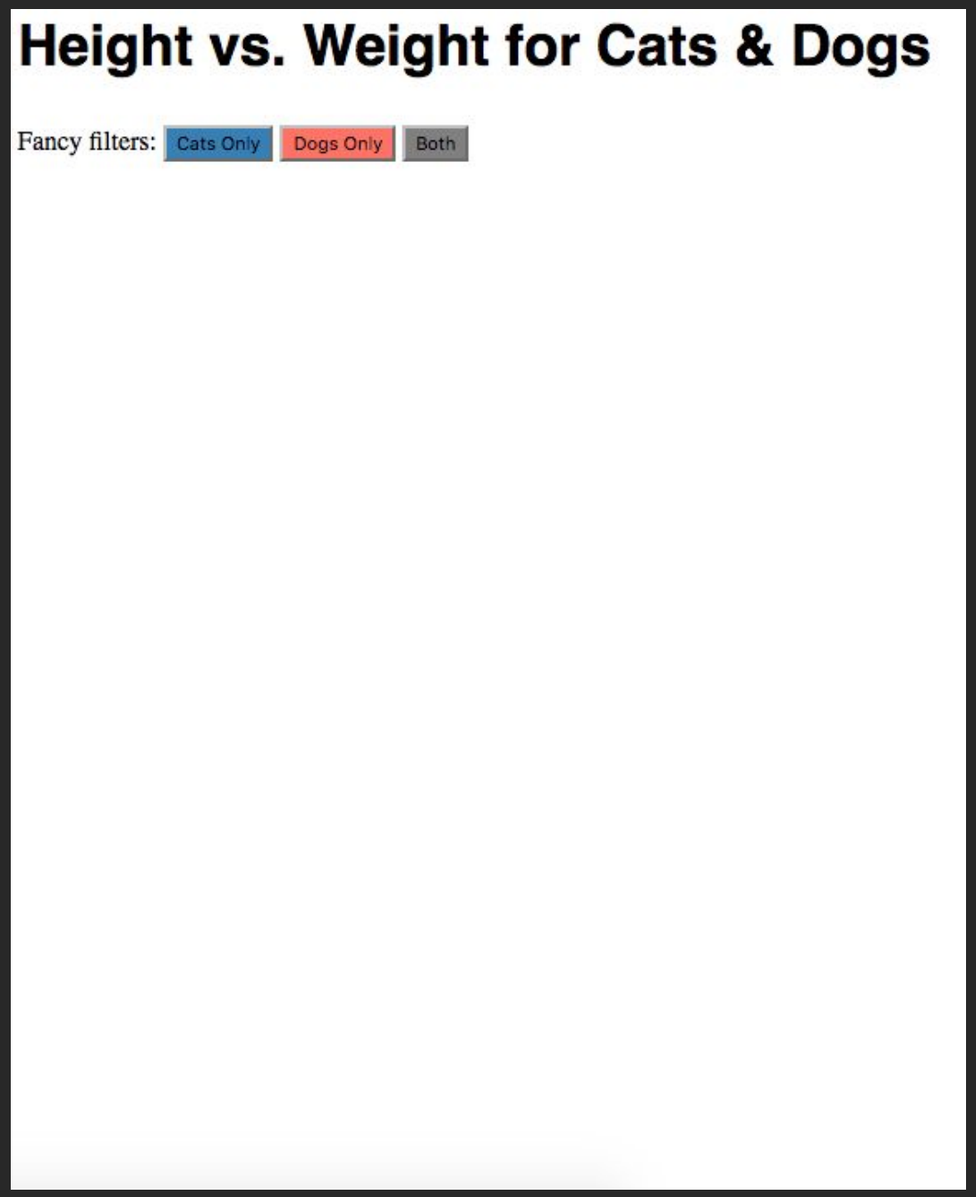
1. Setup (start server, html boilerplate, link D3 src)
2. Define canvas, scales, axes
3. Load data
4. Bind data
5. Draw marks
6. Interactive update with enter/exit

Start with HTML structure & basic CSS

```html
<html>
  <head>
    <meta charset="utf-8">
    <title>🐱 vs. 🐶 stats</title>
    <style>
      /*<!— Write CSS here —>*/
    </style>
    <script src="https://d3js.org/d3.v4.min.js"></script>
  </head>
  <body>
    <!— Write some HTML here —>
    <svg id="animal-viz"></svg>
    <script>
    // Write some JavaScript here!
    </script>
  </body>
</html>
```

Start with HTML structure & basic CSS

```html
<html>
  <head>
    <meta charset="utf-8">
    <title>🐱 vs. 🐶 stats</title>
    <style>
      h1 {
        font-size: 50px;
        font-family: Helvetica, sans-serif;
      }
      button#cats-only {
        background-color: steelblue;
      }
      button#dogs-only {
        background-color: salmon;
      }
      button#both {
        background-color: grey;
      }
    </style>
    <script src="https://d3js.org/d3.v4.min.js"></script>
  </head>
  <body>
    <section>
      <h1>Height vs. Weight for Cats &amp; Dogs</h1>
      <span> Fancy filters: </span>
      <button id="cats-only" data-filter="cat">Cats Only</button>
      <button id="dogs-only" data-filter="dog">Dogs Only</button>
      <button id="both" data-filter="both">Both</button>
    </section>
    <svg id="animal-viz"></svg>
    <script>
    // Write some JavaScript here!
    </script>
  </body>
</html>
```



How do I get this to show up?

Run it on a local server! Use your browser to render the html.

> cd path/to/your/project
> python -m SimpleHTTPServer [if using Python2.x]
> python -m http.server [if using Python 3.x]

```
$ python -m http.server
Serving HTTP on 0.0.0.0 port 8000 ...
```

In your browser, visit: http://localhost:<port> [see number above]

Note: The server you start in your project directory looks for a file called "index.html" to render when you visit localhost:<port>

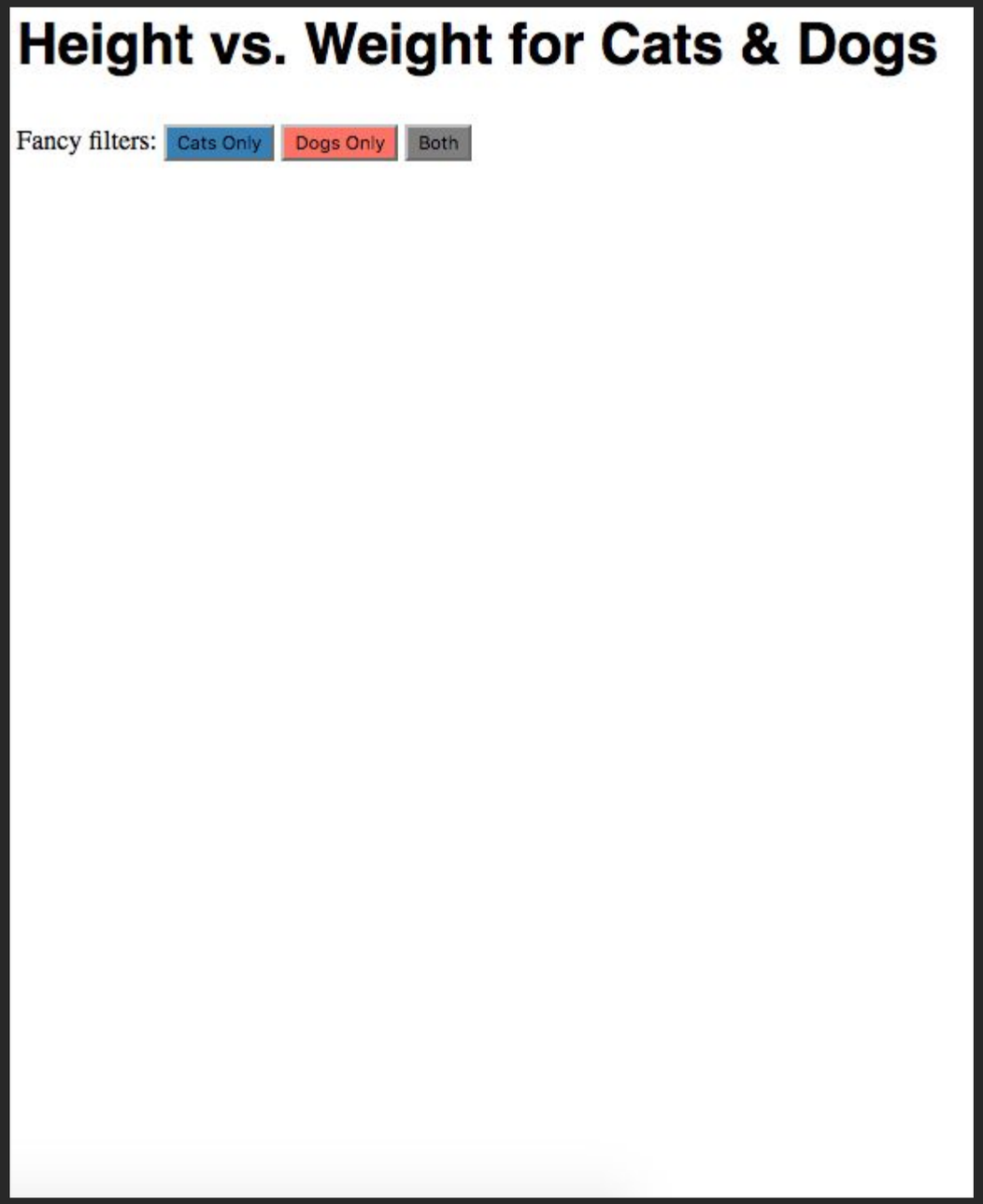
An easy way to start is to put all your JS, HTML, CSS in this file.
[Not recommended for big projects.]

Let's write some D3.js!

Note: all code is contained within the `<script></script>` tags

Selections

```
// Select the `<svg id="animal-viz"></svg>` DOM
let wholeChart = d3.select('#animal-viz');

// Set size of the plot and spacing around it (
let plotWidth = 500;
let plotHeight = 500;
let plotMargin = 50;
let outerWidth = plotWidth + 2 * plotMargin;
let outerHeight = plotHeight + 2 * plotMargin;

// Set the size of the whole chart
// We could have done this in CSS too,
// since it's not dependent on our data
wholeChart
  .attr('width', outerWidth)
  .attr('height', outerHeight);
```



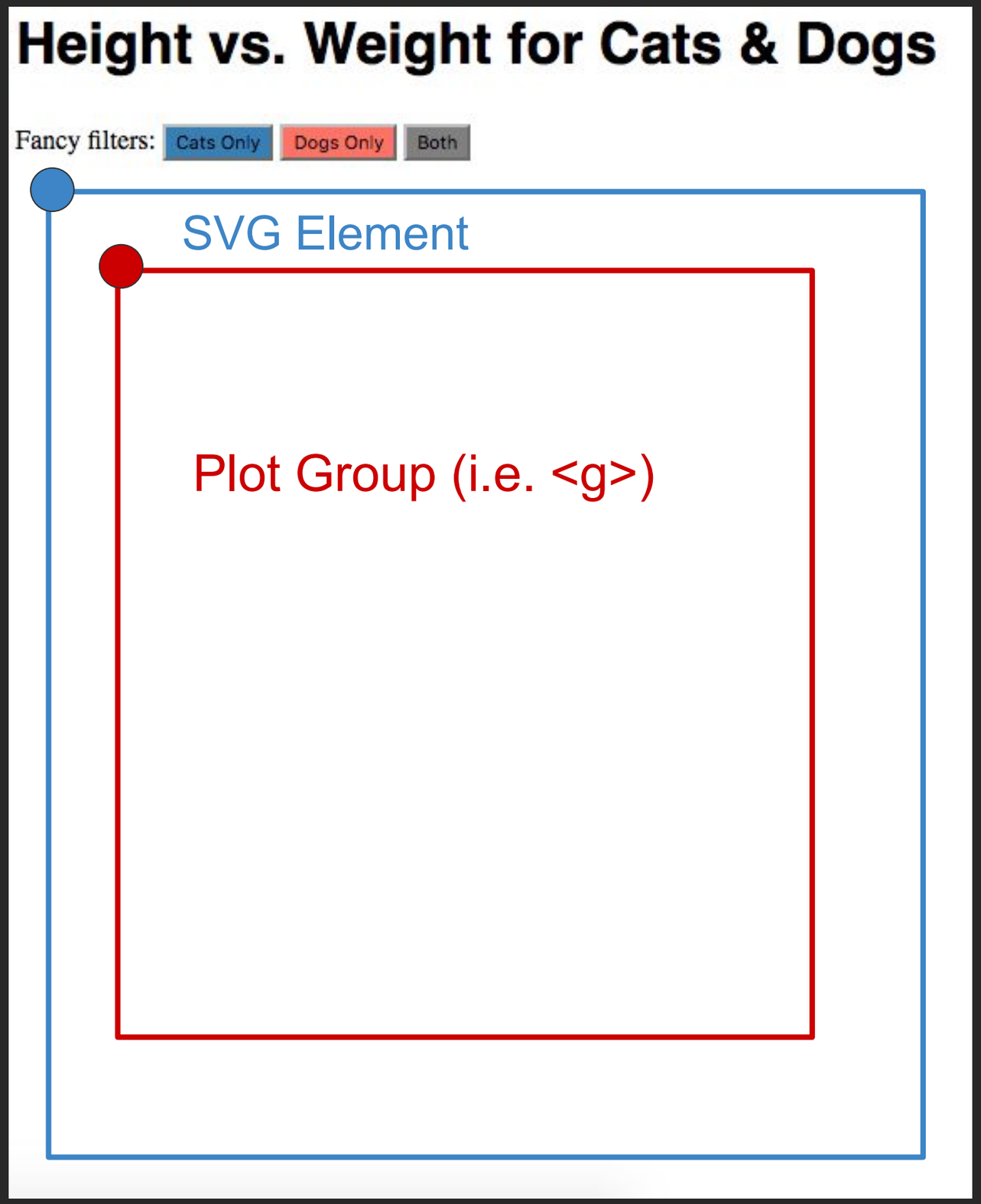
- Can select by any CSS selector
- Chain methods to set attributes
- https://github.com/d3/d3-selection
- https://developer.mozilla.org/en-US/docs/Web/API/Document/querySelector

SVG Coordinates

```
// Append a `g` element to our SVG: we'll work in this for our plot
// It has margins
let plot = wholeChart.append('g')
  .attr('transform', `translate(${plotMargin},${plotMargin})`);
```

Use transforms on <g> to define a new origin
(e.g., plotting area)

SVG Coordinates



Scales

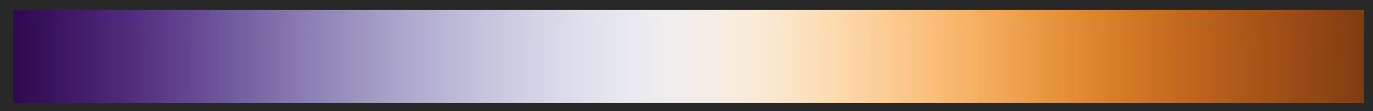
```
let xScale = d3.scaleLinear()
  .domain([0, 10])
  .range([0, plotWidth]);
let yScale = d3.scaleLinear()
  .domain([0, 10])
  .range([plotHeight, 0]); // S
```

- A scale is a function.
- This function maps your data "space" to the encoding "space".
- E.g. 10lbs → 253 px from origin
- Can also make nominal/ordinal scales, map to colors, interpolate between colors, ...
- https://github.com/d3/d3-scale

Data / Domain: [10, 11, 12, 13, 14, 15 …, 26]

`scale(data)` ↓

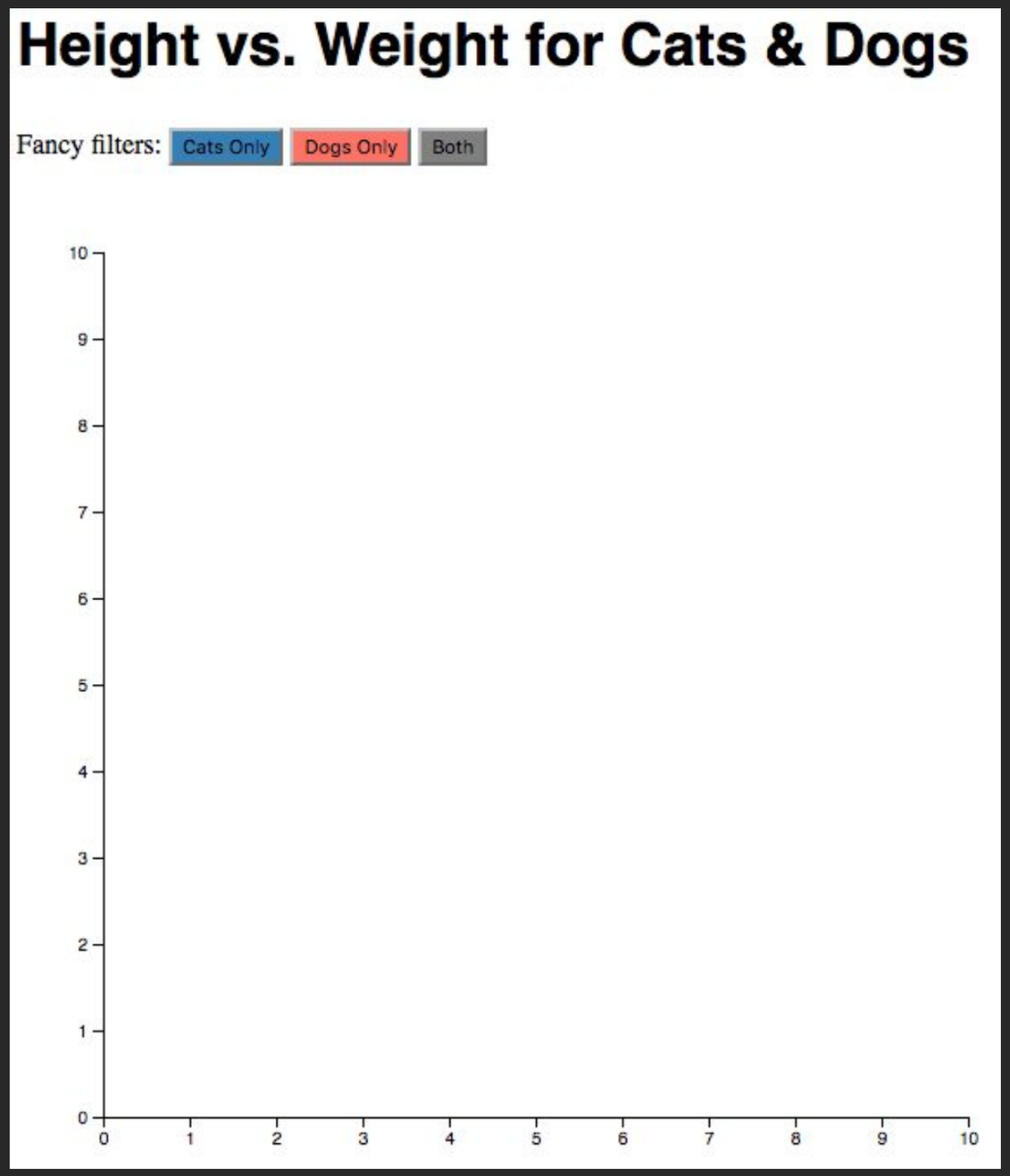
Encoding / Range:



Drawing axes

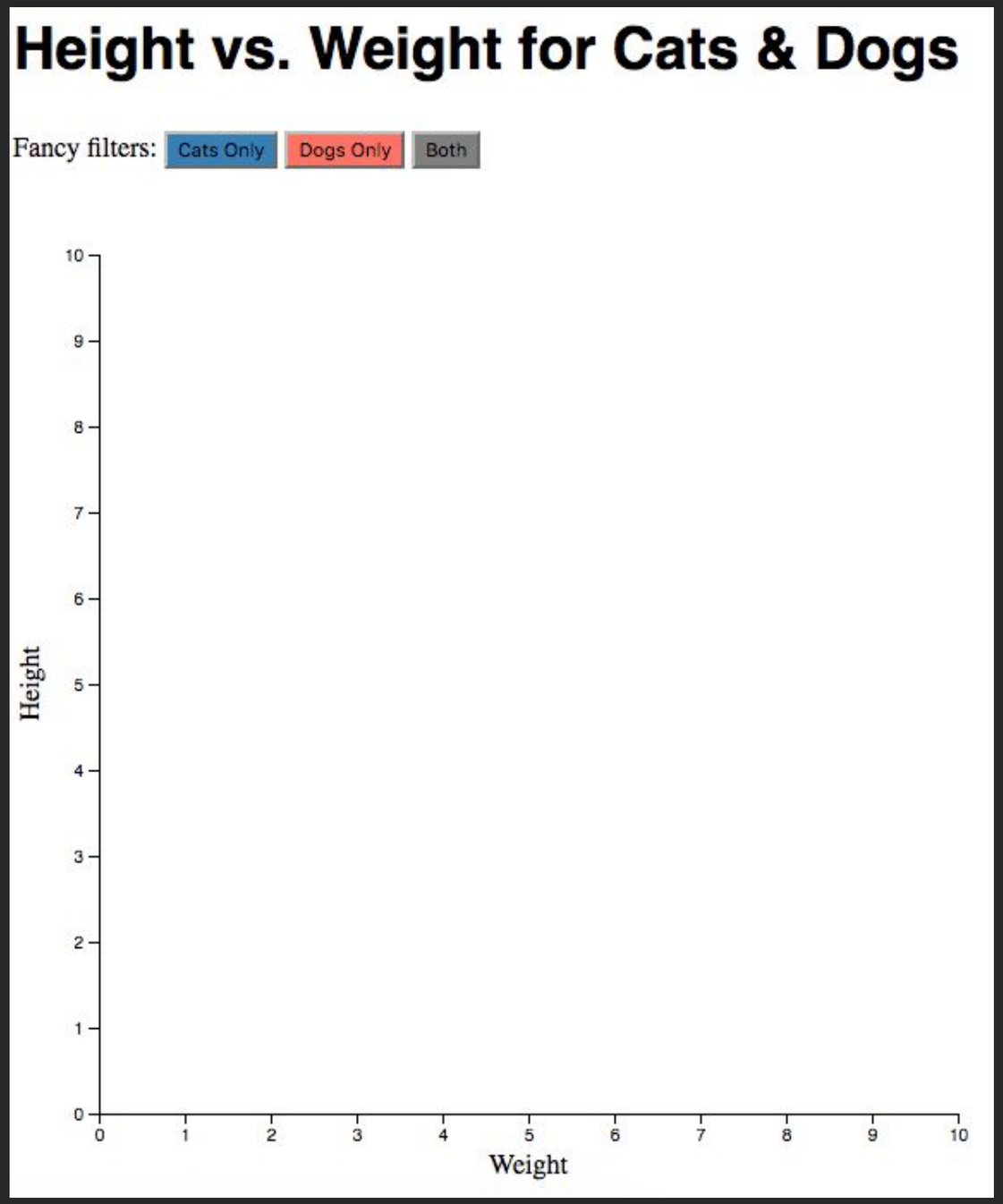
```
// Draw our axes based on xScale and yScale
let xAxis = plot.append('g')
  .attr('transform', `translate(0,${plotHeight})`)
  .call(d3.axisBottom(xScale));
let yAxis = plot.append('g')
  .call(d3.axisLeft(yScale));
```

- `d3.axisBottom(xscale)` returns a function
- We create a new 'g' node, then apply that function to it.
- D3 draws it for us. ✧
- https://github.com/d3/d3-axis



Drawing labels: More svg...

```
// Label the x axis, halfway along the
let xAxisLabel = plot.append('text')
  .attr('x', plotWidth / 2)
  .attr('y', plotHeight + 35)
  .style('text-anchor', 'middle')
  .text('Weight');

// Label the y axis,
let yAxisLabel = plot.append('text')
  .attr('transform', 'rotate(-90)')
  .attr('y', -35) // Actually moving le
  .attr('x', - (plotHeight / 2)) // Mov
  .style('text-anchor', 'middle')
  .text('Height');
```



Recap: What do we have so far?

```
// Select the `<svg id="animal-viz"></svg>` DOM node
let wholeChart = d3.select('#animal-viz');

// Set size of the plot and spacing around it (for axes and label
let plotWidth = 500;
let plotHeight = 500;
let plotMargin = 50;
let outerWidth = plotWidth + 2 * plotMargin;
let outerHeight = plotHeight + 2 * plotMargin;

// Set the size of the whole chart
// We could have done this in CSS too,
// since it's not dependent on our data
wholeChart
  .attr('width', outerWidth)
  .attr('height', outerHeight);

// Append a `g` element to our SVG: we'll work in this for our pl
// It has margins
let plot = wholeChart.append('g')
  .attr('transform', `translate(${plotMargin},${plotMargin})`);

// Create our scales,
// each of which will map data from 0-10 to the size of our plot
let xScale = d3.scaleLinear()
  .domain([0, 10])
  .range([0, plotWidth]);
let yScale = d3.scaleLinear()
  .domain([0, 10])
  .range([plotHeight, 0]); // SVG has its origin in the top left,

// xScale and yScale are functions:
// xScale(0) => 0; xScale(10) => 500; xScale(2) => 100
// yScale(0) => 500; yScale(10) => 0; yScale(2) => 400

// Draw our axes based on xScale and yScale
let xAxis = plot.append('g')
  .attr('transform', `translate(0,${plotHeight})`)
   .call(d3.axisBottom(xScale));
let yAxis = plot.append('g')
  .call(d3.axisLeft(yScale));

// Label the x axis, halfway along the width of the plot, 35 px u
let xAxisLabel = plot.append('text')
  .attr('x', plotWidth / 2)
  .attr('y', plotHeight + 35)
  .style('text-anchor', 'middle')
  .text('Weight');

// Label the y axis,
let yAxisLabel = plot.append('text')
  .attr('transform', 'rotate(-90)')
  .attr('y', -35) // Actually moving left, since we rotated
  .attr('x', - (plotHeight / 2)) // Move vertically down halfway
  .style('text-anchor', 'middle')
  .text('Height');
```

```
// Select the `<svg id="animal-viz"></svg>` DOM node
let wholeChart = d3.select('#animal-viz');

// Set size of the plot and spacing around it (for axes and label
let plotWidth = 500;
let plotHeight = 500;
let plotMargin = 50;
let outerWidth = plotWidth + 2 * plotMargin;
let outerHeight = plotHeight + 2 * plotMargin;

// Set the size of the whole chart
// We could have done this in CSS too,
// since it's not dependent on our data
wholeChart
  .attr('width', outerWidth)
  .attr('height', outerHeight);

// Append a `g` element to our SVG: we'll work in this for our pl
// It has margins
let plot = wholeChart.append('g')
  .attr('transform', `translate(${plotMargin},${plotMargin})`);

// Create our scales,
// each of which will map data from 0-10 to the size of our plot
let xScale = d3.scaleLinear()
  .domain([0, 10])
  .range([0, plotWidth]);
let yScale = d3.scaleLinear()
  .domain([0, 10])
  .range([plotHeight, 0]); // SVG has its origin in the top left,

// xScale and yScale are functions:
// xScale(0) => 0; xScale(10) => 500; xScale(2) => 100
// yScale(0) => 500; yScale(10) => 0; yScale(2) => 400

// Draw our axes based on xScale and yScale
let xAxis = plot.append('g')
  .attr('transform', `translate(0,${plotHeight})`)
   .call(d3.axisBottom(xScale));
let yAxis = plot.append('g')
  .call(d3.axisLeft(yScale));

// Label the x axis, halfway along the width of the plot, 35 px u
let xAxisLabel = plot.append('text')
  .attr('x', plotWidth / 2)
  .attr('y', plotHeight + 35)
  .style('text-anchor', 'middle')
  .text('Weight');

// Label the y axis,
let yAxisLabel = plot.append('text')
  .attr('transform', 'rotate(-90)')
  .attr('y', -35) // Actually moving left, since we rotated
  .attr('x', - (plotHeight / 2)) // Move vertically down halfway
  .style('text-anchor', 'middle')
  .text('Height');
```

Define the chart container.

Define the plot dimensions.

Set the chart container's attributes.

Add a group (<g>) for the actual plot.

Define the scales.

Draw the axes on the plot group.

Draw the axis labels.

Data loading & joining

🚨 *This is important!* 🚨

Loading the data from an external file

```
// Fetch the data, transfrom it, load it
d3.csv('animals.csv', parseInputRow, loadData);

// Convert weight and height from strings to numb
function parseInputRow(d) {
  return {
    id: +d.id,
    animal: d.animal,
    weight: +d.weight,
    height: +d.height,
    name: d.name
  };
}

function loadData (error, animalData) {
  if (error) throw error; // Runs if there's a pr

  // animalData looks like [
  //  {animal: "cat", weight: 10, height: 3},
  // ... ]

  // Draw the initial scatter plot
  drawScatterPlot(animalData);
}
```

- Load the CSV, then pass the data through 2 callback functions.
- First function runs on each row, parsing it.
- https://github.com/d3/d3-request#csv

Drawing the scatter plot

```
function drawScatterPlot(animalData) {
  // Create a selection of circles in our plot (empty on the first go)
  let circles = plot.selectAll('circle');

  // Bind our animal data to the circles, using the "id" field as our key
  let updatedCircles = circles.data(animalData, d => d.id);

  // We'll use "enter" to make circles for new datapoints
  let enterSelection = updatedCircles.enter();
  let newCircles = enterSelection.append('circle')
    .attr('r', 20)
    .attr('cx', function (d) { return xScale(d.weight); })
    .attr('cy', function (d) { return yScale(d.height); })
    .style('fill', function(d) {
      return d.animal === 'cat' ? 'steelblue' : 'salmon';
    });

  // Now we'll select all the circles that no longer
  // have any corresponding data after the data join
  let unselectedCircles = updatedCircles.exit();
  // And we'll remove those nodes form the DOM - poof!
  updatedCircles.exit().remove();
}
```

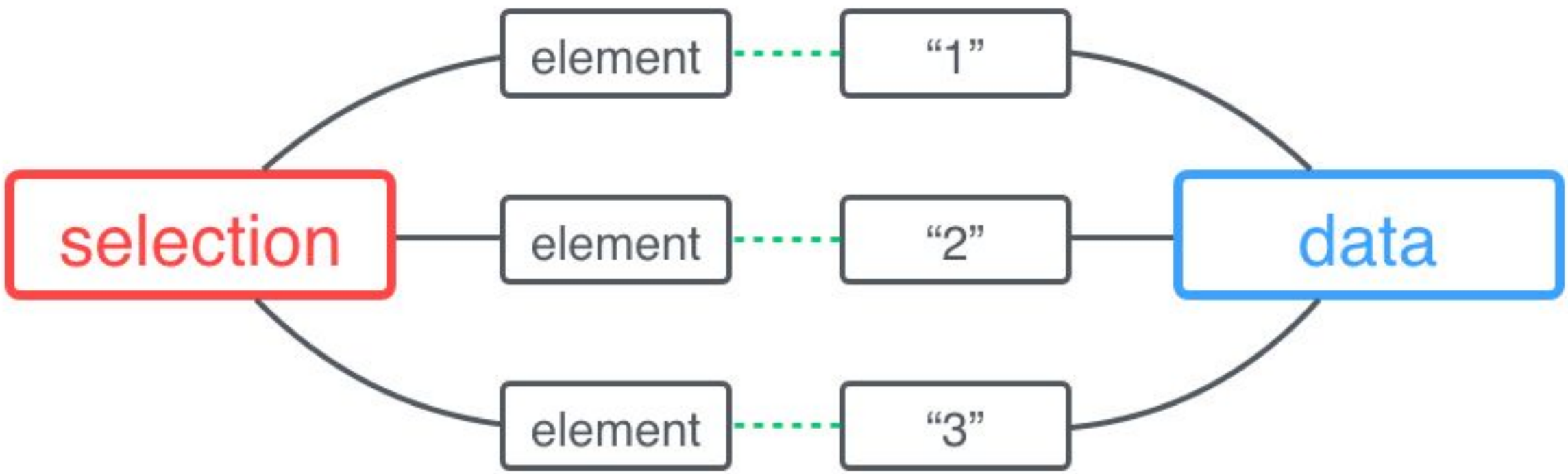
Selection + data

```
function drawScatterPlot(animalData) {
  // Create a selection of circles in our plot (empty on the first go)
  let circles = plot.selectAll('circle');

  // Bind our animal data to the circles, using the "id" field as our key
  let updatedCircles = circles.data(animalData, d => d.id);
```

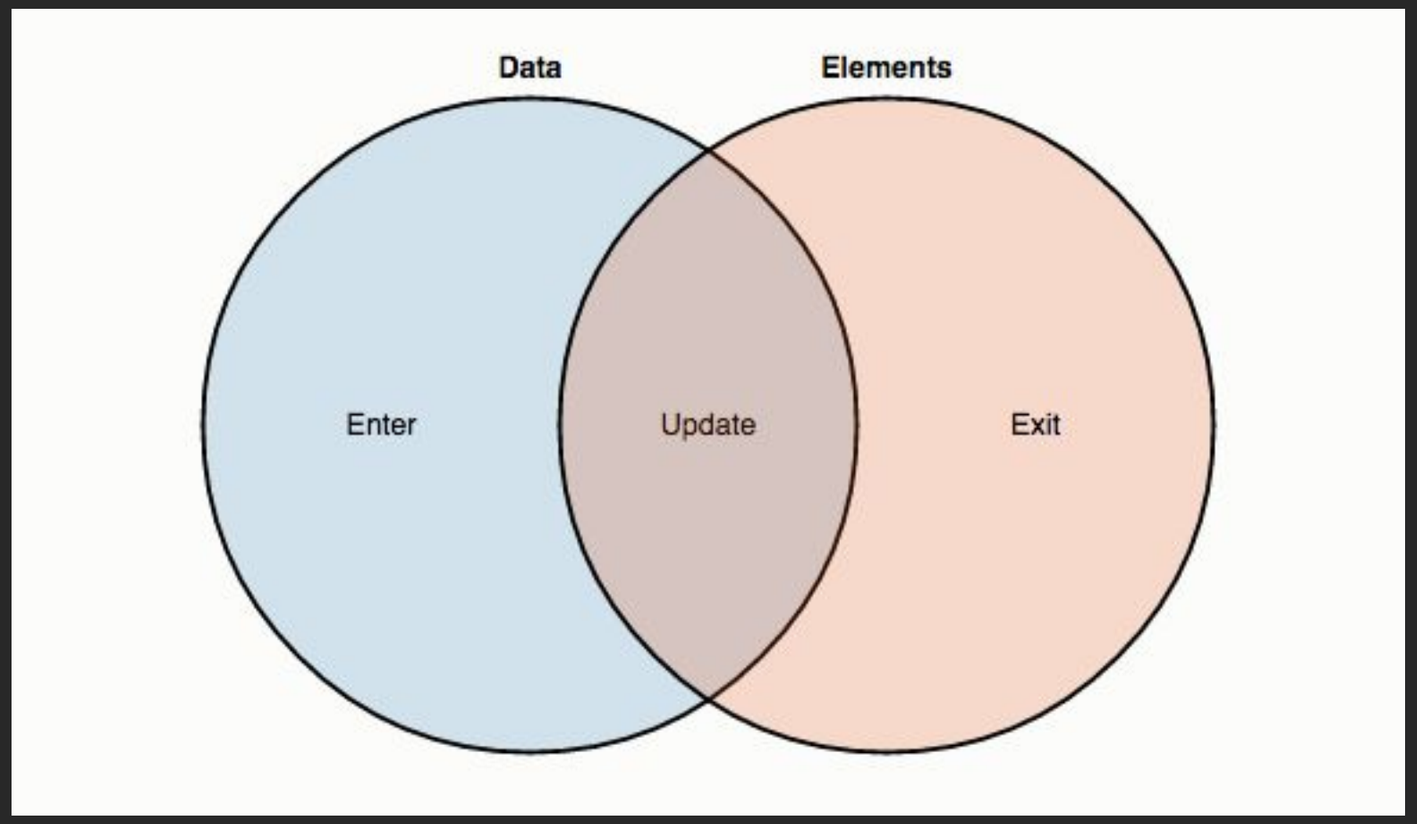
- .data() takes an array of data, and joins it to a selection
  - Returns a new selection, called the "update" selection
  - Note: .data() does not draw anything!

- 2nd arg is a "key function"
  - Tells D3 how to match the data with the elements in the selection
  - By default, uses index in array as key

What's happening when you join data?



What's happening when you join data?



3 sub-selections:

- *Enter*: New data, missing elements
- *Update*: Data points joined to existing elements
- *Exit*: Leftover unbound elements

Enter selection + appending circles

```
// We'll use "enter" to make circles for new datapoints
let enterSelection = updatedCircles.enter();
let newCircles = enterSelection.append('circle')
  .attr('r', 20)
  .attr('cx', function (d) { return xScale(d.weight); })
  .attr('cy', function (d) { return yScale(d.height); })
  .style('fill', function(d) {
    return d.animal === 'cat' ? 'steelblue' : 'salmon';
  });
```

- `enter()`
  joins the update data with the data that is already bound.

- `append()`
  draws circles for the data in the join.

- Canonical Explanation:
  https://github.com/d3/d3-selection#selection_enter :

Exit selection + removing nodes

```
  // Now we'll select all the circles that no longer
  // have any corresponding data after the data join
  let unselectedCircles = updatedCircles.exit();
  // And we'll remove those nodes form the DOM - poof!
  updatedCircles.exit().remove();
}
```

- `exit()`
  selects the data that is not contained by the join.
- `remove()`
  removes the circles for that data.
- Doesn't do anything now, but it will once we add interactive filtering...

Learn more about data-joining and "general update pattern"

Chris Given's Block 32d4c53f19aea6e528faf10bfe4f3da9
Updated July 29, 2017

Popular / About

Interactive General Update Pattern

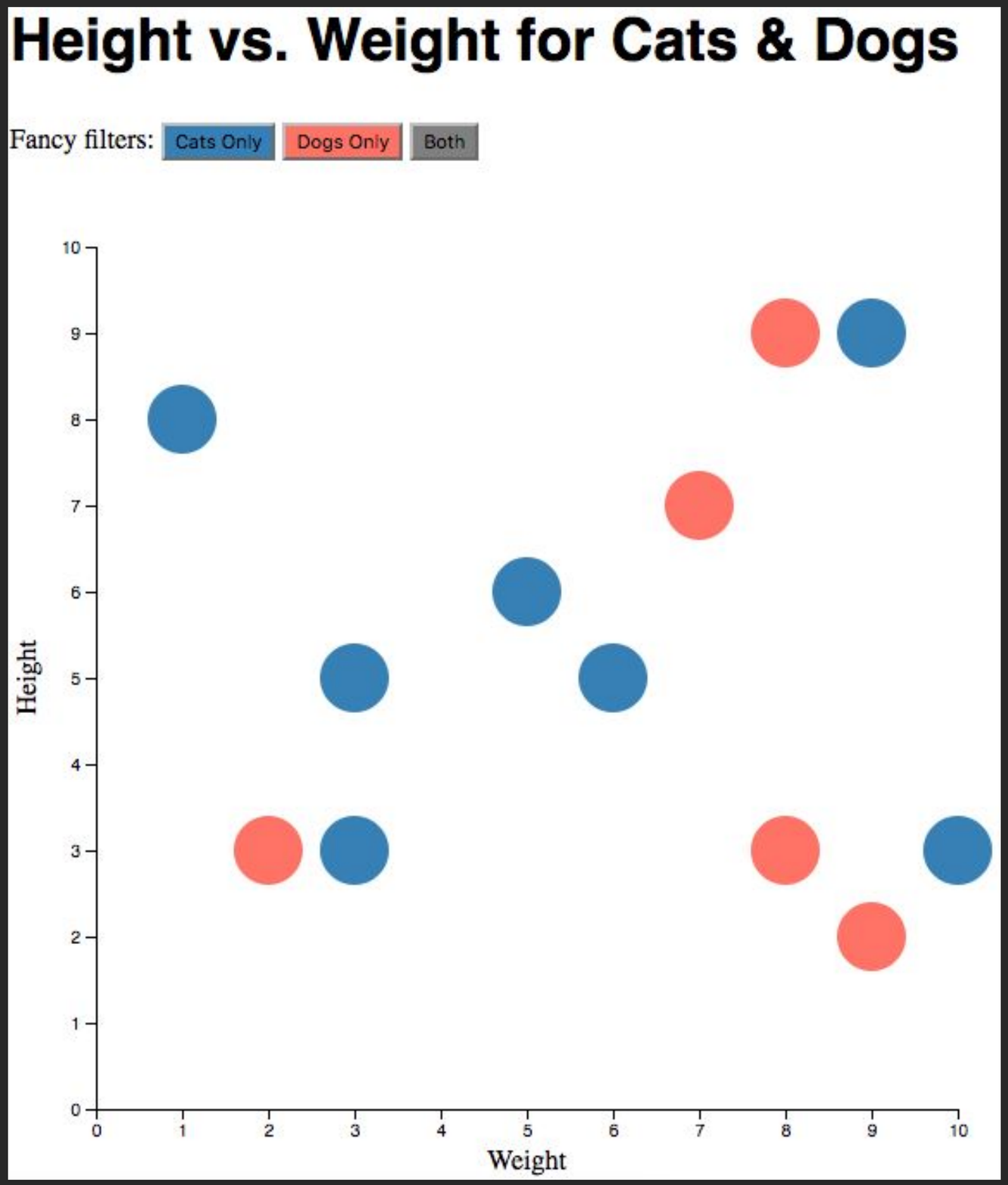
```
function update(data) {

    var update = svg.selectAll('circle')
        .data(data, function (d) { return d })

    var enter = update.enter()
        .append('circle')

    var exit = update.exit()

    update.style('fill', 'black')

    enter.style('fill', 'green')

    exit.style('fill', 'red')
        .remove()

    update.merge(enter)
        .call(pulse)

}
```

```
data = ["a", "b", "c", "d", "f", "g"]
```

.enter() Although we're showing letters in the top left to illustrate that D3 knows about them, circles that correspond to these letters don't yet exist. By calling .enter() on the update selection, we select these non-existent circles, so that…

https://bl.ocks.org/cmgiven/32d4c53f19aea6e528faf10bfe4f3da9

🎉 Circles!


Height vs. Weight for Cats & Dogs
Fancy filters:
Cats Only
Dogs Only
Both
Height
Weight
0
1
2
3
4
5
6
7
8
9
10

Drawing the scatter plot

```
function drawScatterPlot(animalData) {
  // Create a selection of circles in our plot (empty on the
  let circles = plot.selectAll('circle');

  // Bind our animal data to the circles, using the "id" fie
  let updatedCircles = circles.data(animalData, d => d.id);

  // We'll use "enter" to make circles for new datapoints
  let enterSelection = updatedCircles.enter();
  let newCircles = enterSelection.append('circle')
    .attr('r', 20)
    .attr('cx', function (d) { return xScale(d.weight); })
    .attr('cy', function (d) { return yScale(d.height); })
    .style('fill', function(d) {
      return d.animal === 'cat' ? 'steelblue' : 'salmon';
    });

  // Now we'll select all the circles that no longer
  // have any corresponding data after the data join
  let unselectedCircles = updatedCircles.exit();
  // And we'll remove those nodes form the DOM - poof!
  updatedCircles.exit().remove();
}
```

Select all the circles.

Bind the data.
(i.e. update)

Join the data.

Draw the data.

Get the unmatched data.

Remove it.

Interactivity

```
let buttons = d3.selectAll('button');
buttons.on('click', function() {
  // When you write a function for a D3 selection with multiple nodes
  // `this` refers to the current DOM node
  let chosenAnimal = this.dataset.filter; // value of `data-filter` attr
  let filteredData;
  if (chosenAnimal === 'both') {
    filteredData = animalData;
  } else {
    filteredData = animalData.filter( d => d.animal === chosenAnimal );
  }
  drawScatterPlot(filteredData);
});
```

- In our script tag, add event listeners to the buttons.
- When you click on a button,
  - filter the dataset
  - redraw the plot

- D3 has an interface for this, but you can also use plain JavaScript
  `addEventListener()`

Interactivity

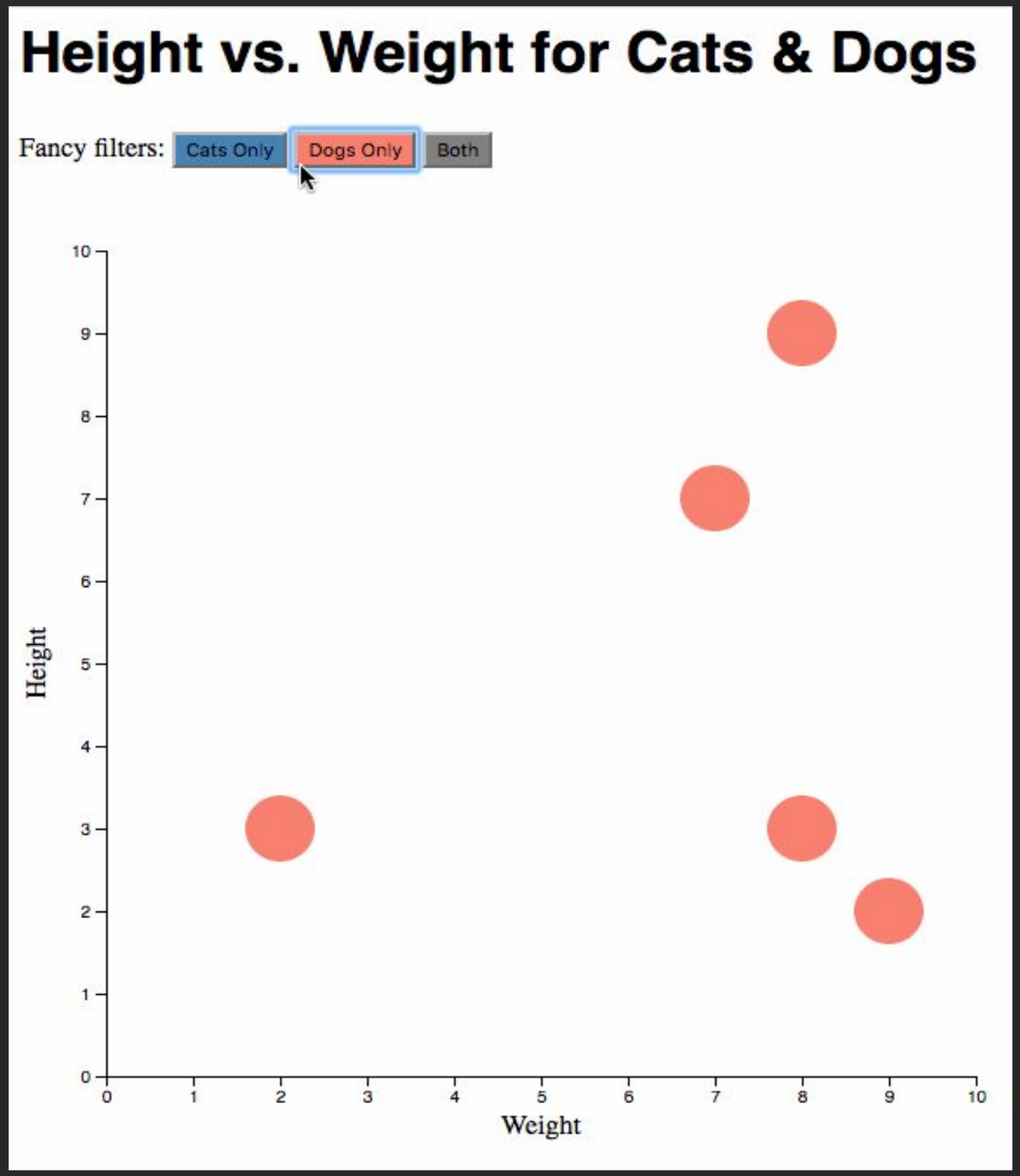
- Because **`drawScatterPlot`** uses **`id`** as a key function, it knows what is entering/exiting when we filter, then rebind the data

```
// Bind our animal data to the circles, using the "id" field as our key
let updatedCircles = circles.data(animalData, d => d.id);
```

- You **could** just remove all circles, then redraw new ones based on your filtered data.

- But the strength of data joining is that D3 can see what's changed between your existing selection's data and the new data.

- … and operate efficiently, only on the elements that have changed.



Tips

- Browser showing old code?
  cmd-shift-r, hard refresh and clear the cache.
- Use the inspector console.
  console.log() is your friend,
- Reset your server, if all else fails.
- Avoid using a framework.
  Unnecessary complexity.
- Use HTML inputs as needed
- CSS can simplify simple interactions

```
.circle:hover {
    fill: yellow;
}
```

Other things D3 can do for you

Different scales

- Ordinal scale (discrete domain and range)
- Colors as range
  - Interpolation between colors for diverging scales
  - Predefined discrete color schemes
- https://github.com/d3/d3-scale/blob/master/README.md

d3.schemeCategory10 <>

An array of ten categorical colors represented as RGB hexadecimal strings.

d3.**schemeCategory20** <>

An array of twenty categorical colors represented as RGB hexadecimal strings.

d3.**schemeCategory20b** <>

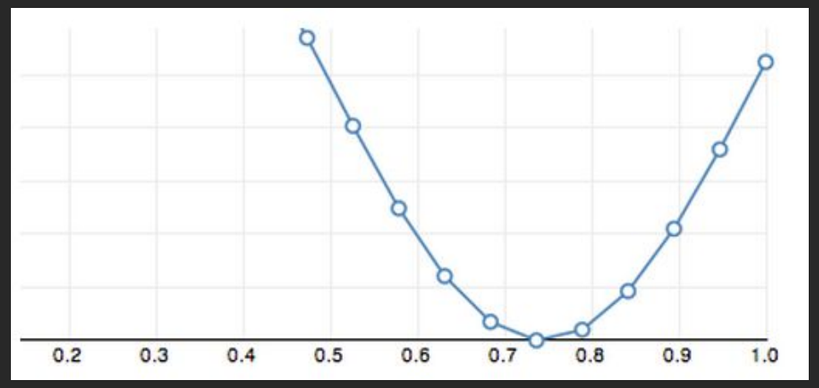
An array of twenty categorical colors represented as RGB hexadecimal strings.

d3.**schemeCategory20c** <>

An array of twenty categorical colors represented as RGB hexadecimal strings. This color scale includes color specifications and designs developed by Cynthia Brewer (colorbrewer2.org).

Paths and areas

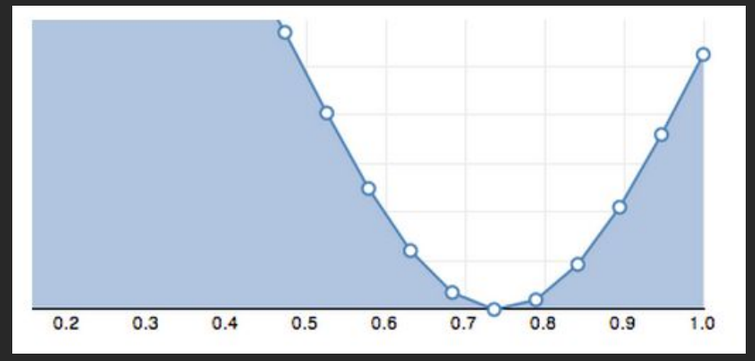
d3.line
https://github.com/d3/d3-shape/blob/master/README.md#line



```
<path d="M152.64962091501462,320.5600780855698L133.
88913955606318,325.4363177123538L134.96890954443046
,330.3791763492199 6L131.19348249532786,331.15839361
4812L98.5668110962881 5,335.5393380785700 4L91.144507
99488135,333.79662025279L72.1880101321918,333.74733
970068166L69.51723455785742,332.8569681440152L62.37
3139113540 66,333.2100666843387L62.24833430913743 4,3
35.3677272708405L58.84344098888326,335.05749596050
36L53.97667317221 4221,331.3607512563317 5L56.30952738
```

Paths and areas

d3.area
https://github.com/d3/d3-shape/blob/master/README.md#area

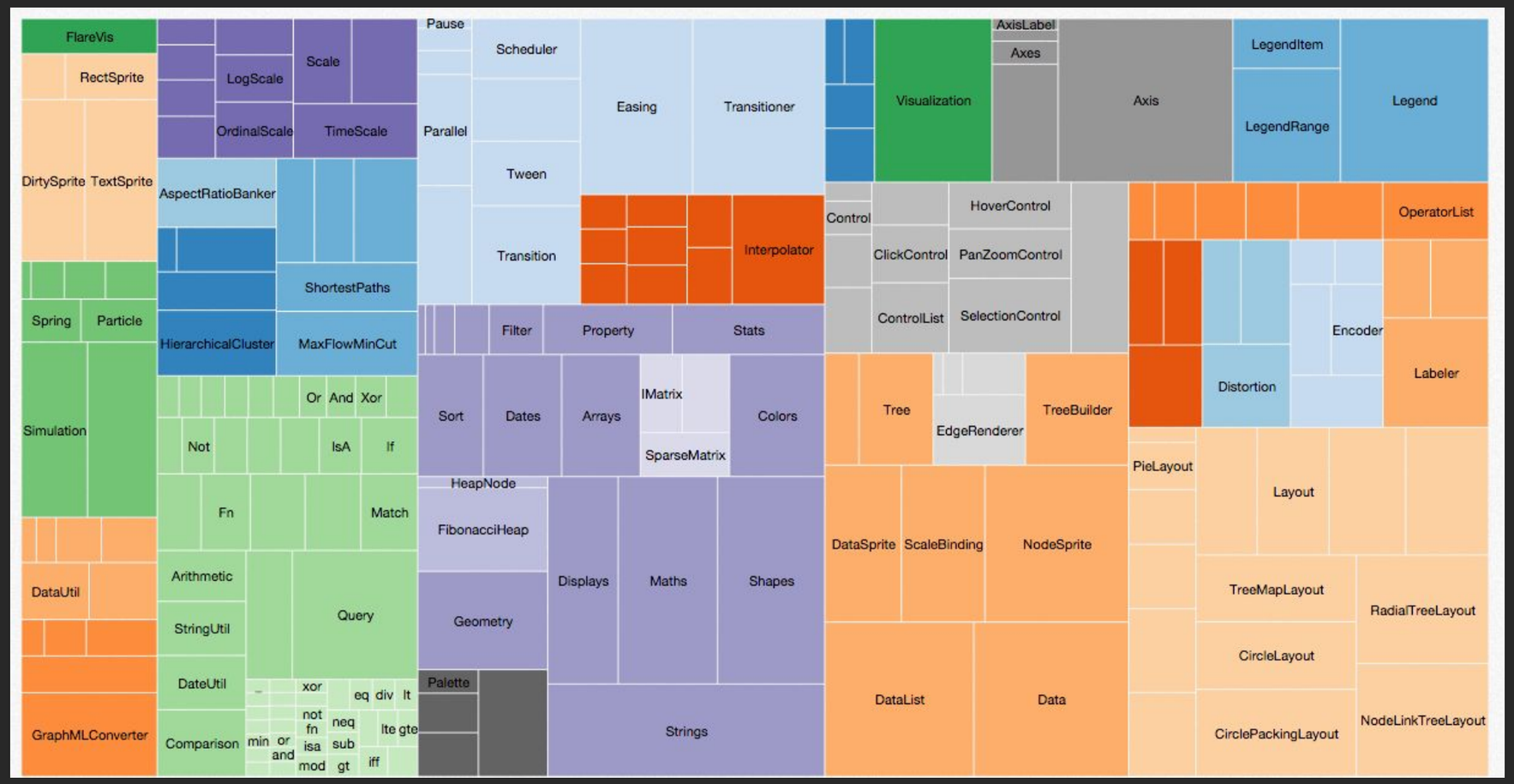


Paths and areas

d3.geoPath
https://github.com/d3/d3-geo/blob/master/README.md#geoPath

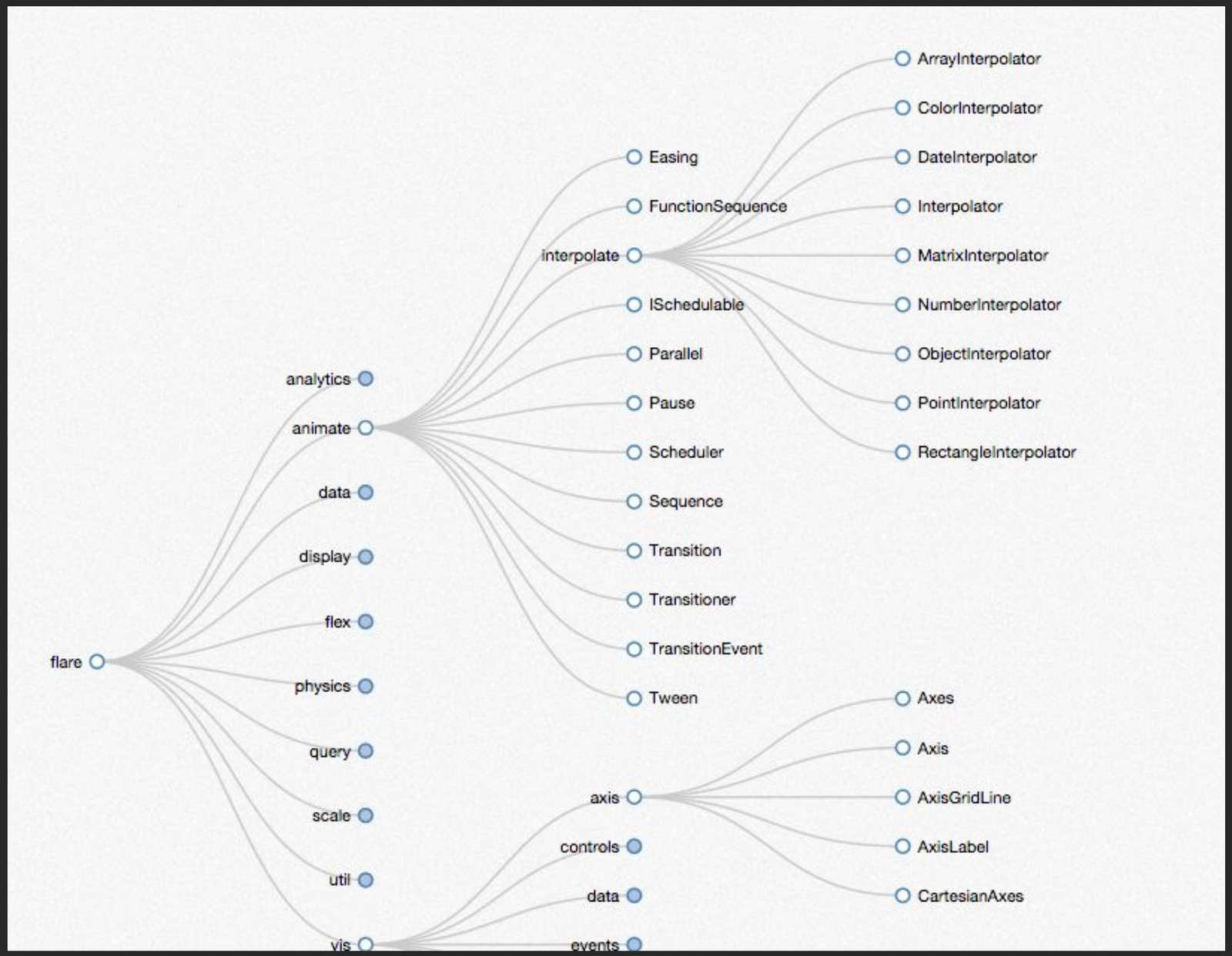
Hierarchical layouts

d3.treemap
https://github.com/d3/d3-hierarchy/blob/master/README.md#treemap



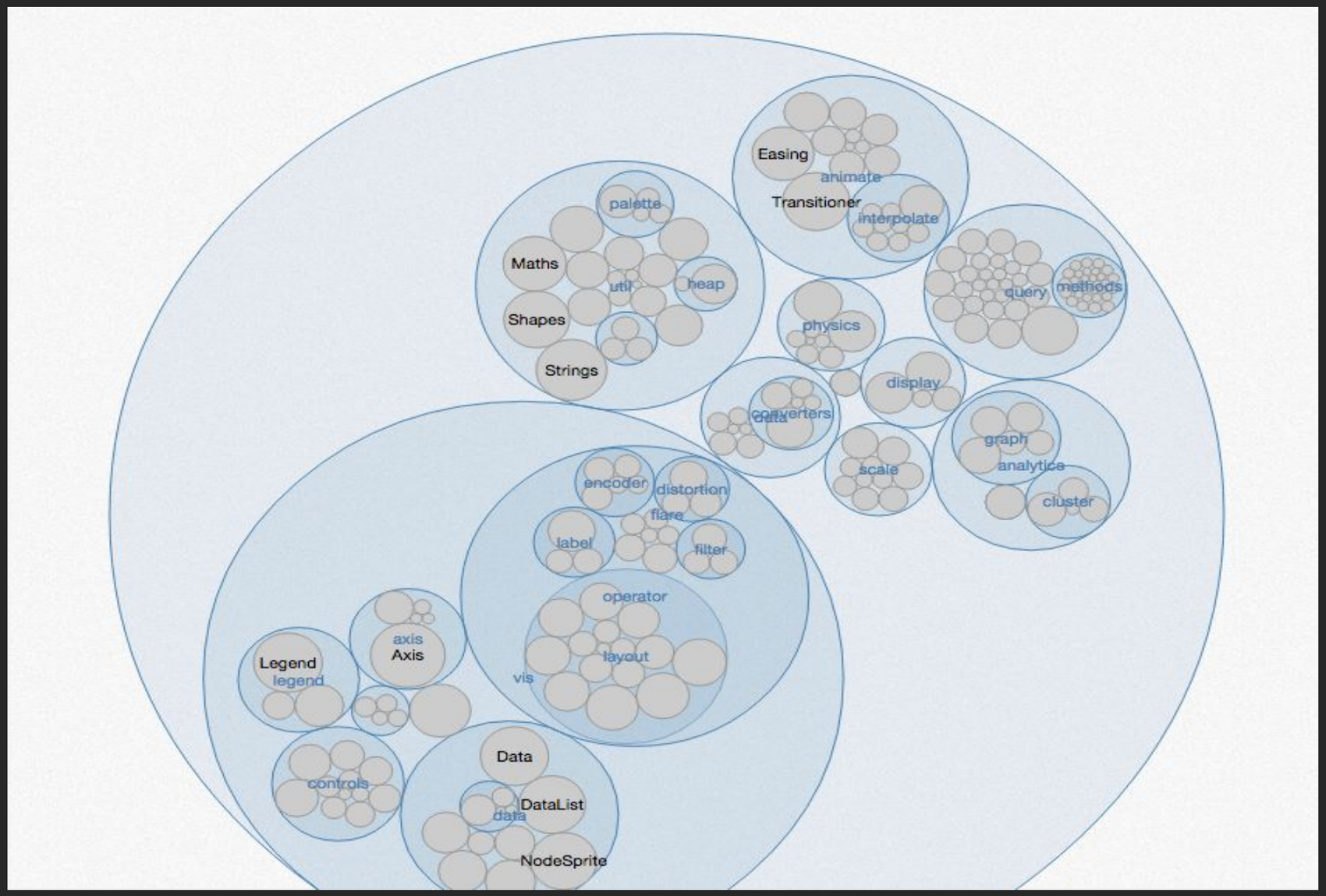
Hierarchical layouts

d3.tree
https://github.com/d3/d3-hierarchy/blob/master/README.md#tree



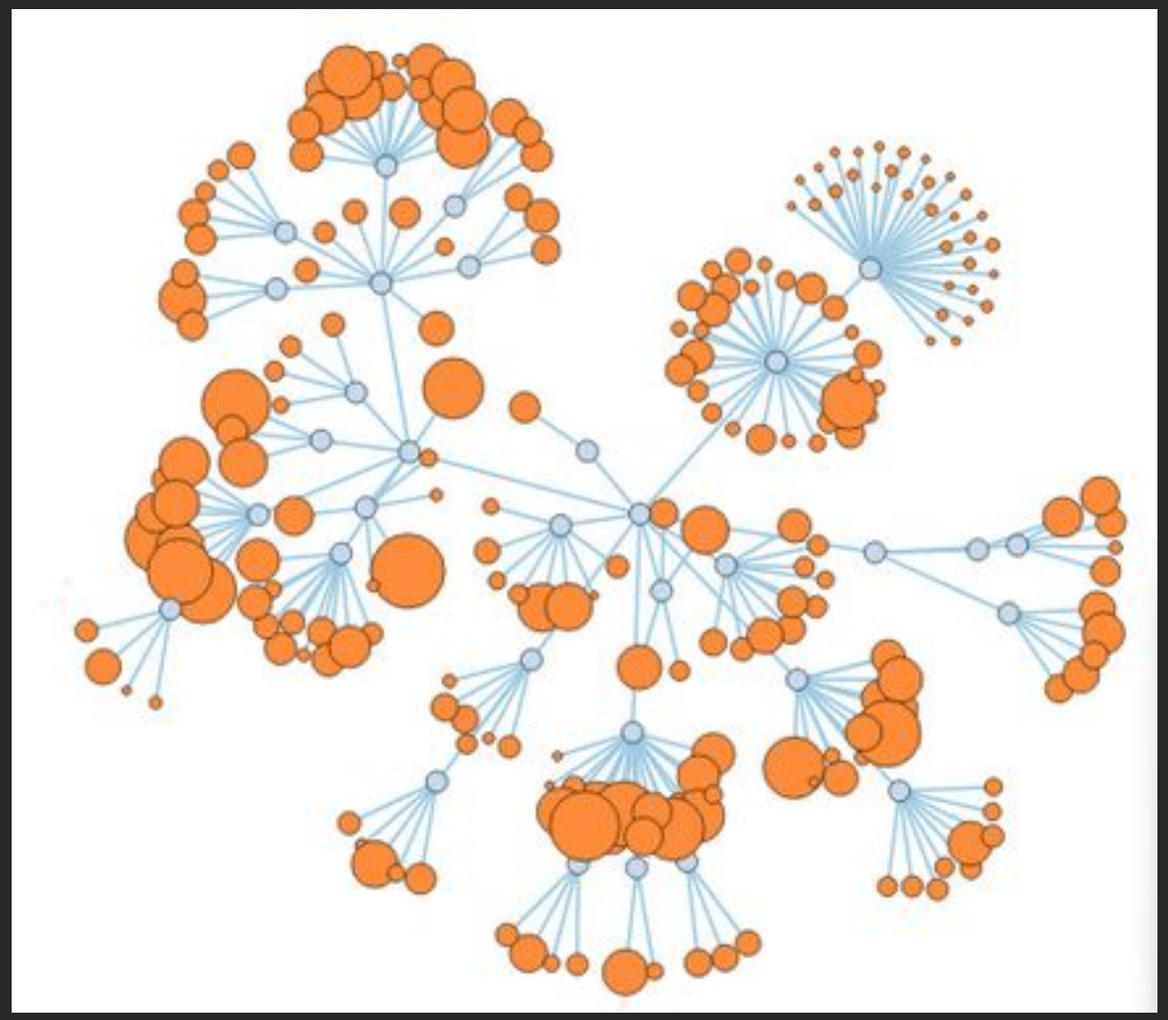
Hierarchical layouts

d3.pack
https://github.com/d3/d3-hierarchy/blob/master/README.md#pack



Network layout

d3.forceSimulation
https://github.com/d3/d3-force



Resources

D3 API Documentation at
https://github.com/d3/d3/blob/master/API.md

Example code

- Mike Bostock
  - Drag + zoom: https://bl.ocks.org/mbostock/3127661b6f13f9316be745e77fdfb084
- Also Scott Murray, Jerome Cukier

Slack team: https://d3-slackin.herokuapp.com/

✧ More resources on the website homepage and Piazza!