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# D3: The Crash Course



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CSE 6242: Data and Visual Analytics

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But first...

Baby Name >   Both  Boys  Girls

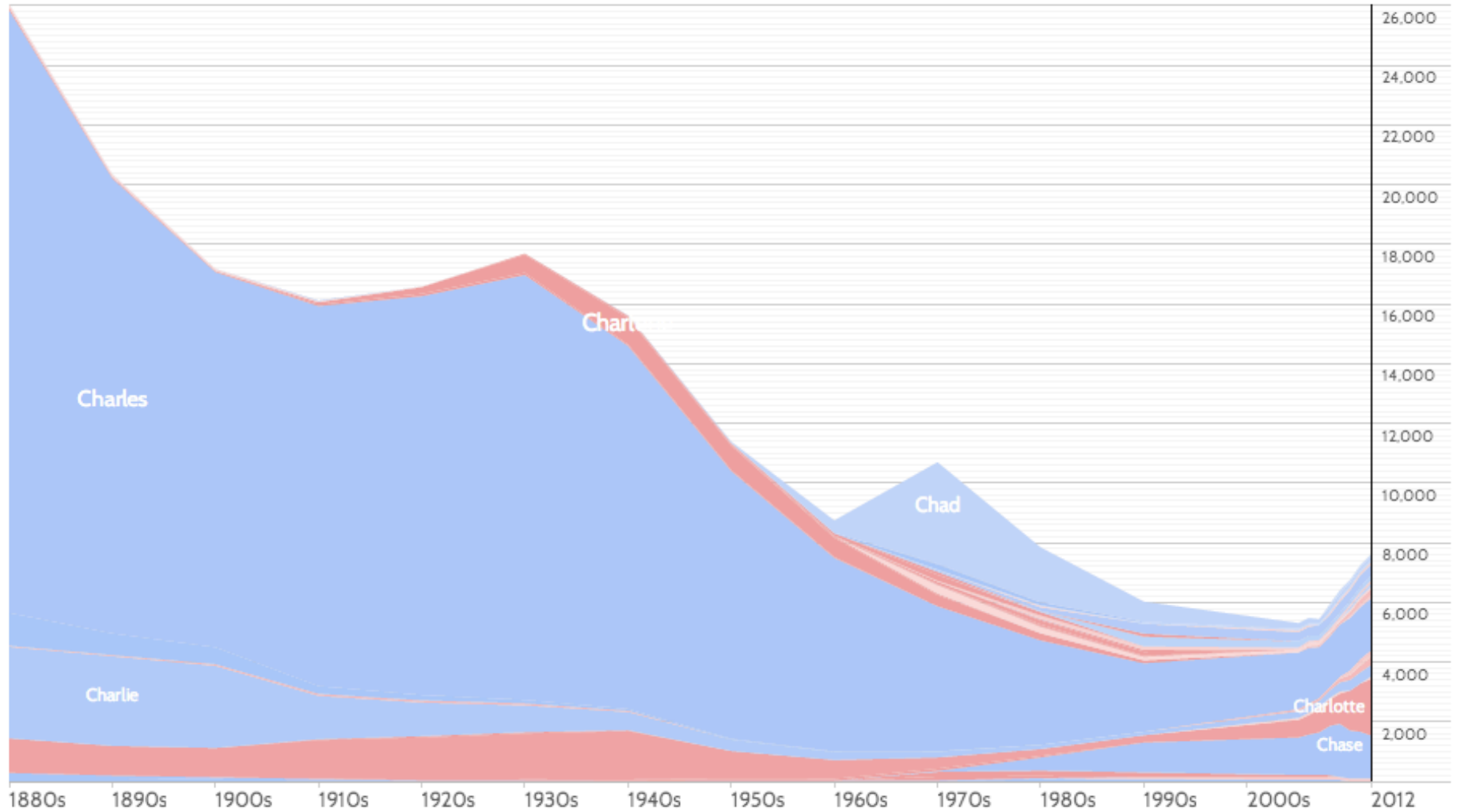
Current rank: boys 

1000	500	100	25	1
------	-----	-----	----	---

  
girls 

1000	500	100	25	1
------	-----	-----	----	---

Names starting with 'CHA' per million babies



Click a name graph to view that name. Double-click to read more about it.

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# D3: The Crash Course



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CSE 6242: Data and Visual Analytics

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# D3: Scratching the Surface

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D3: Only the Beginning

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Please do not be afraid to ask questions!

- 
- History
  - Website...
    - Directory Structure
    - Development
  - Javascript 101-2
  - SVG Basics
  - D3.js Crash Course



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<http://bl.ocks.org/mbostock/1256572>

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Mike Bostock and Jeff Heer @ Stanford

2009- Protovis

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# Mike Bostock and Jeff Heer @ Stanford

2009- Protovis

2011- D3.js

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Who has some programming experience?

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Who has some web development experience?

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# Website Directory Structure

- (Replace “project” with a real name)
- project/
  - index.html
- project/lib/
  - d3.v3.js
- project/js/
  - project.js
- project/css/
- project/img/

---

# Chrome Inspector and Console

- Open the webpage
- Right-click on anything
- Click inspect this element
- Click on the  $\geq$  button at the very bottom to open the console as well
  - (2<sup>nd</sup> from the left)

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# Starting a Local Webserver

- `python -m SimpleHTTPServer 8000`
- <http://localhost:8000>



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How many of you have experience with  
Javascript?

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# Javascript 101

- All variables are global unless declared using `var`
  - `x = 300` (global) vs. `var x = 300` (local)
- Semicolons are completely optional
- “text” is the same as ‘text’
- JS arrays and objects are almost exactly the same syntax as python’s lists and dicts
- `object.key` is the same as `object[‘key’]`
- Print to the console using `console.log( )`

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# Javascript 102: Functional Programming

- Javascript is a *functional language*
  - Functions are themselves objects
  - Functions can be stored as variables
  - Functions can be passed as parameters
- D3 uses these abilities extensively!

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# Javascript 102: Functional Programming

- Javascript is a *functional language*
  - Functions are themselves objects
  - Functions can be stored as variables
  - **Functions can be passed as parameters**
- D3 uses these abilities extensively!

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## Array.map( )

- Used for applying a function to each element of an array
- The function provided as a parameter takes one parameter itself:
  - d: a/each data point
- [https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global\\_Objects/Array/map](https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Array/map)

---

## Array.map( )

- `var x = [{val:1},{val:2},{val:3},{val:4}]`
- `var a = x.map(function(d){  
    return d.val;  
})`
- `a : [1,2,3,4]`

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# MDN

- Mozilla Developer Network
- <https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference>
- (Easier: google “<command> mdn”)

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# Method Chaining

- Programming paradigm where each method returns the object that it was called on
- Simply put:  
`group.attr("x",5).attr("y",5) //returns group`  
is the same as  
`group.attr("x",5) //returns group`  
`group.attr("y",5) //returns group`



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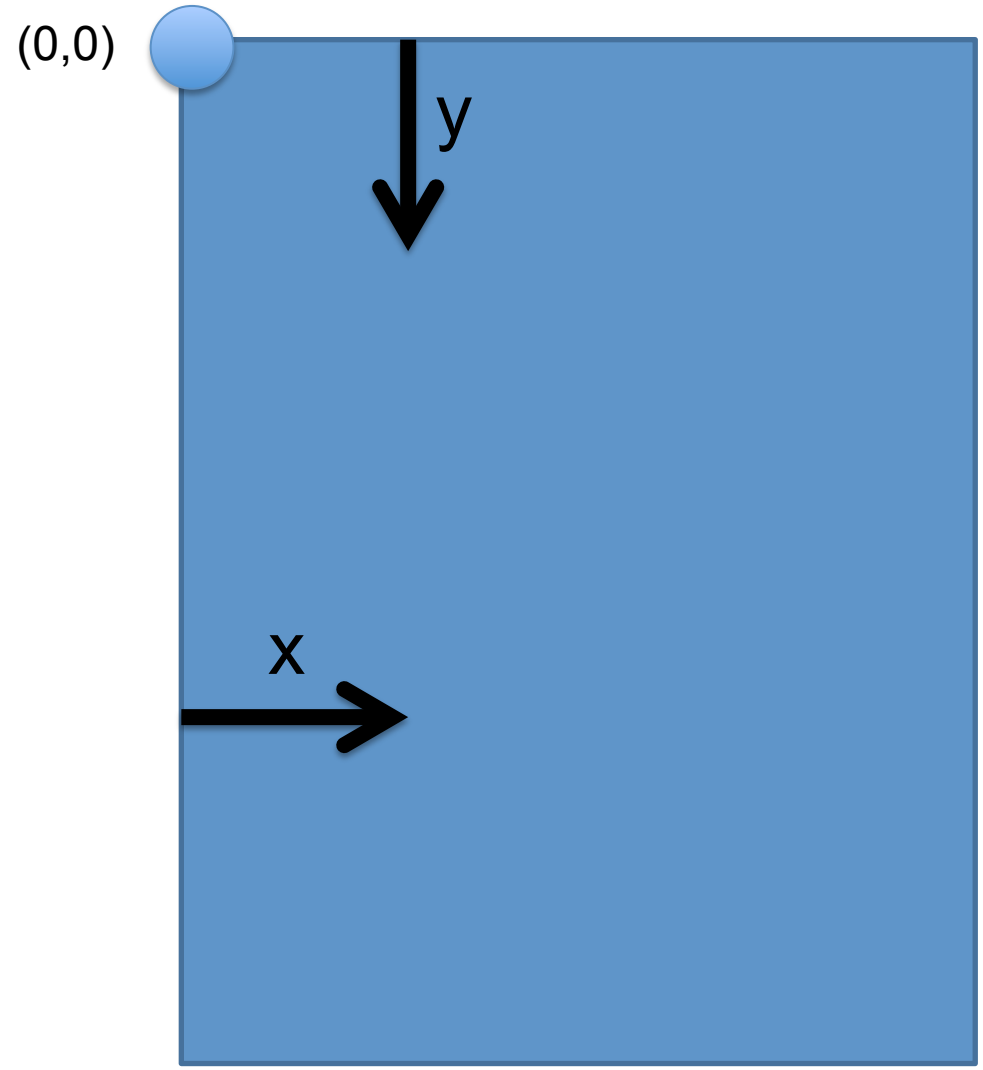
# SVG BASICS

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How many of you have experience with  
SVG?

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How many have experience with 2D  
computer graphics (such as Java Swing)?



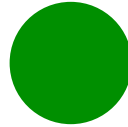
---

# SVG Basics

## XML Vector Graphics

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# SVG Basics

- XML Vector Graphics
  - Tags with Attributes
  - `<circle r=5 fill="green"></circle>` 
- W3C Standard
  - <http://www.w3.org/TR/SVG/>
- Supported by all the major browsers

---

# SVG Basics

- `<svg>`
- `<circle>`
- `<rect>`
- `<path>`
- `<g>`

-

---

# SVG Basics

- `<svg>`
- `<circle>`
- `<rect>`
- `<path>`
- `<g>`
  
- `<text>` (after I've talked about D3)



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## <svg> element

- Overarching canvas
- (optional) Attributes:
  - width
  - Height
- Create with
  - `d3.select("#vis").append("svg:svg")`

---

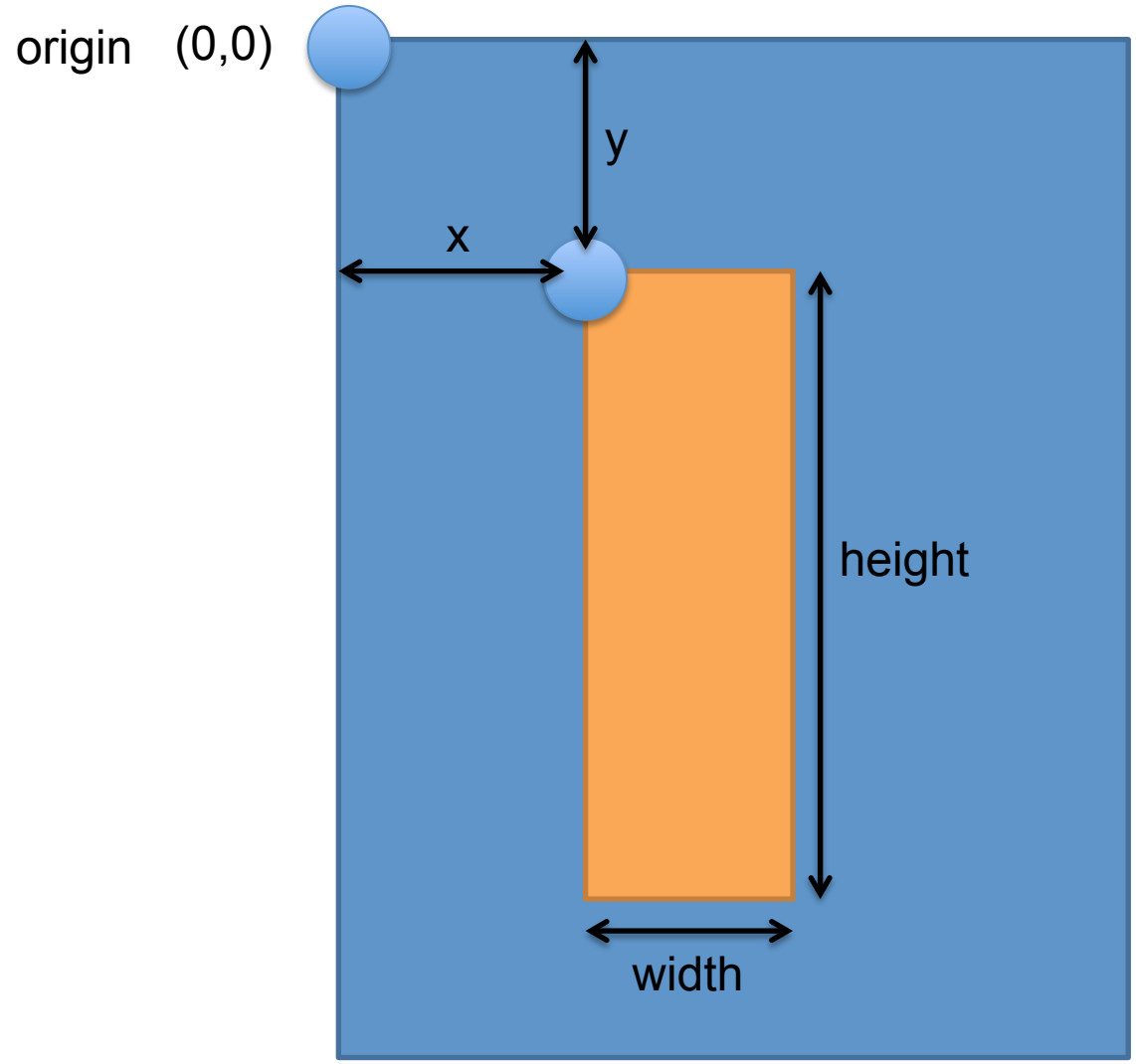
## <circle> element

- Attributes:
  - cx (relative to the LEFT of the container)
  - cy (relative to the TOP of the container)
  - r (radius)
- (optional) Attributes:
  - fill (color)
  - stroke (the width of the stroke)
  - stroke-fill (the color of the stroke)
- Create with
  - `.append("svg:circle")`

---

## <rect> element

- Attributes:
  - x (relative to the LEFT of the container)
  - y (relative to the TOP of the container)
  - width (cannot be negative)
  - height (cannot be negative)
- (optional) Attributes:
  - fill (color)
  - stroke (the width of the stroke)
  - stroke-fill (the color of the stroke)
- Create with
  - `.append("svg:rect")`



---

Rather than positioning each element,  
what if we want to position *all* the  
elements?

---

## <g> element

- Generic container (Group) element
- Attributes
  - transform
- Create with:
  - `var group = vis.append("svg:g")`
- Add things to the group with:
  - `group.append("svg:circle")`
  - `group.append("svg:rect")`
  - `group.append("svg:text")`

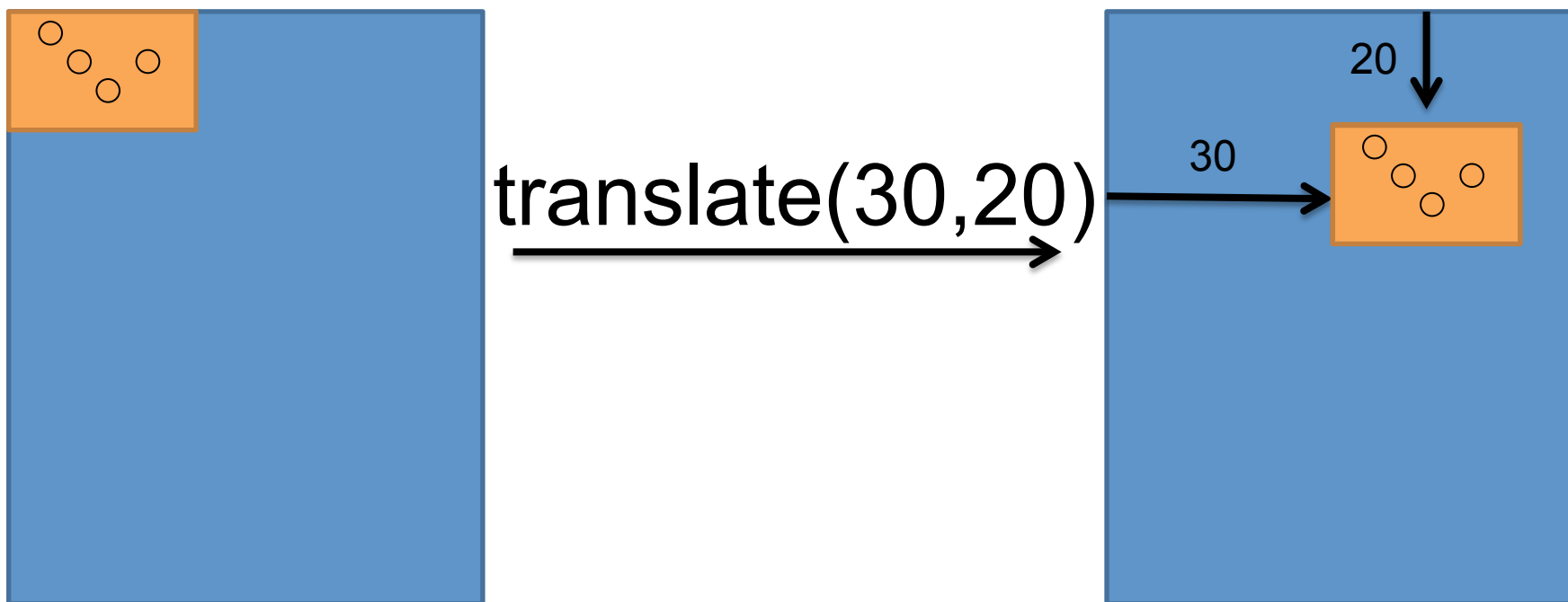
---

# Transform Property

“transform”, “translate(x,y)”

---

`.attr("transform", "translate(x,y)")`





---

AND NOW D3...

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# D3

- Grand Reductionist Statements
- Loading Data
- Enter-Update-Exit Paradigm
- Scales
- Axes
- Layouts
- Transitions and Interaction
  
- Where to go from here

---

D3 is a really powerful for-loop  
with a ton of useful helper functions

---

# D3

- Declarative, domain-specific specification language for visualization
- i.e.
  - Define a template for each type of element
  - D3 draws one element for each data point

---

# Importing D3

```
<html >
  <head>
    <meta charset="UTF-8">
    <script src='lib/d3.v3.js'></script>
    <script src='js/project.js'></script>
  </head>
  <body>
    <div id="vis"></div>
  </body>
</html>
```

---

# Assigning the Canvas to a Variable

```
vis = d3.select("#vis")  
  .append("svg:svg")
```

```
<body>
```

```
  <div id="vis"><svg></svg></div>
```

```
</body>
```

---

# Loading Data

- `d3.csv(fileloc, callback)`
- `d3.json(fileloc, callback)`
  
- `fileloc`: string file location
  - “data/datafile.csv”
- `callback`: `function(rawdata){ }`

---

# rawdata from a CSV file

```
[
  {
    'name': 'Adam',
    'school': 'GT',
    'age': '18'
  },
  {
    'name': 'Barbara',
    'school': 'Emory',
    'age': '22'
  },
  {
    'name': 'Calvin',
    'school': 'GSU',
    'age': '30'
  }
]
```

name	school	age
Adam	GT	18
Barbara	Emory	22
Calvin	GSU	30



---

# Problem

```
rawdata: [  
  {  
    'name': 'Adam',  
    'school': 'GT',  
    'age': '18'  
  },  
  {  
    'name': 'Barbara',  
    'school': 'Emory',  
    'age': '22'  
  },  
  {  
    'name': 'Calvin',  
    'school': 'GSU',  
    'age': '30'  
  }  
]
```

- Ages are Strings, not ints.
- We can fix that:

```
for(var d: rawdata){  
    d = rawdata[d]  
    d.age = +d.age  
}
```

---

# rawdata from a JSON file

```
[
  {
    'name': 'Adam',
    'school': 'GT',
    'age': 18
  },
  {
    'name': 'Barbara',
    'school': 'Emory',
    'age': 22
  },
  {
    'name': 'Calvin',
    'school': 'GSU',
    'age': 30
  }
]
```

name	school	age
Adam	GT	18
Barbara	Emory	22
Calvin	GSU	30

---

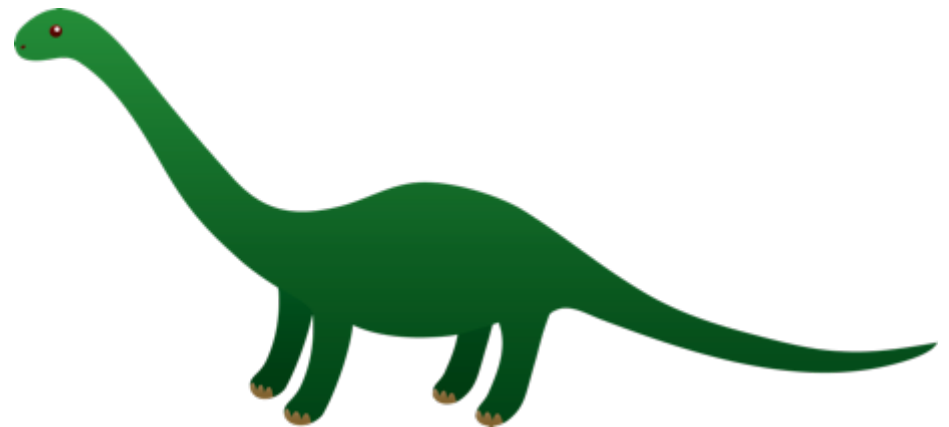
## Enter-Update-Exit

- The *most* critical facet of how D3 works
- If you remember nothing else from today, remember this...
- “Enter-Update-Exit”
- “Enter-Update-Exit”
- “Enter-Update-Exit”

---

# Enter-Update-Exit

- The *most* critical facet of how D3 works
- If you remember nothing else from today, remember this...
- “Enter-Update-Exit”
- “Enter-Update-Exit”
- “Enter-Update-Exit”



---

# Enter-Update-Exit

- Pattern:
  - Select a “group” of “elements”
  - Assign data to the group
  - **Enter:** Create new elements for data points that don't have them yet
  - **Update:** Set the attributes of all the elements based on the data
  - **Exit:** Remove elements that don't have data anymore

---

Can be hard to grok:

You can select groups of elements that  
DON'T EXIST YET

---

## .enter() and .exit()

- .enter()
  - New data points
- .exit()
  - Old data points

---

## .enter() and .exit()

- `.data( [1,2,3,4] )`
- `.data ( [1,2,3,4,5,6] )`
- `.data ( [1,2,3] ) //4,5,6`



---

# Data Key Functions

- `.data(rawdata)` defaults to assuming that the index of the point is the key
- `.data(rawdata, function(d,i){ })` allows you to set a key functions
- e.g.
  - `.data(rawdata, function(d,i){ return d.id; })`
  - `.data(rawdata, function(d,i){ return d.name; })`

---

# E-U-E Pattern Template

```
var group = vis.selectAll("rect")
    .data(rawdata) //rawdata must be an array!
group.enter( ).append("svg:rect") //ENTER!
    .attr( )
    .attr( )
group //UPDATE!
    .attr( )
    .attr( )
group.exit( ).remove( ) //EXIT!
```

---

## .attr()

- The Attribute Method
- Sets attributes such as x, y, width, height, and fill
- Technical details:
  - `rect.attr("x", 5)`
  - `<rect x="5"></rect>`

---

# .attr() and Functional Programming

- [ {size: 10}, {size: 8}, {size: 12.2} ]
- .attr("height", function(d,i){ return d.size })
  - d: the data point
- .attr("x", function(d,i){ return (i+1)\*5; })
  - i: the index of the data point

```
<rect height="10" x="5"></rect>  
<rect height="8" x="10"></rect>  
<rect height="12.2" x="15"></rect>
```

---

# <text> elements

---

## <text> elements

- I'm going to apologize in advance here for the lousy job the w3c did with the <text> definition.
- You're going to have to just either memorize these things or keep referring back to <http://www.w3c.org/TR/SVG/text.html> (first Google hit for "svg text") like I do.

---




## <text> elements

- Extra Method in D3
  - `.text("Your Text Goes Here")`
  - `<tag>Your Text Goes Here</tag>`
- Attributes
  - `x`
  - `y`
- Styles
  - `text-anchor: start, middle, end`
  - `dominant-baseline: [nothing], hanging, middle`

---

## text-anchor style

Where is (0,0)?

 This is my  line of text. 

start

middle

end



---

# dominant-baseline style

Where is (0,0)?

hanging  
middle  
default



This is my line of text.

---

## <text> example

```
group.append("svg:text")  
  .text(function(d){return d.name})  
  .attr("x", function(d,i){return i*5})  
  .attr("y", function(d,i){return height;})  
  .style("dominant-baseline", "hanging")  
  .style("text-anchor", "middle")
```

```
.style("prop1", "val1")
```

```
.style("prop2", "val2")
```

```
<ele style="prop1: val1; prop2: val2;">
```

---

What if you have  
two *different* types of circles?

---

# Classing

- CSS Classes
  - Any number of classes per element
  - Select using “.classname”

```
red = vis.selectAll("circle.redcircle")  
    .data(reddata, function(d){return d.id;})
```

```
red.enter( ).append("svg:circle")  
    .classed("redcircle", "true")
```

```
blue = vis.selectAll("circle.bluecircle")  
    .data(bluedata, function(d){return d.id;})
```

```
blue.enter( ).append("svg:circle")  
    .classed("bluecircle", "true")
```

```
vis.selectAll(".bluecircle").attr("fill", "blue")
```

```
red.attr("fill", "red")
```

- 
- `.attr("height", 5)` is boring
  - `.attr("height", function(d,i){ return i*5; })`  
only works for fixed values
  - `.attr("height", function(d){ return d; })` can  
blow up really quickly...

---

# Scales

---

# Scales

- D3 has many types of scales
- I am only going to cover two:
  - Linear Scales
  - Ordinal Scales

---

# Linear Scales

- `var xscale = d3.scale.linear( )`
  - `.domain( [min, max] )`
  - `.range( [minOut, maxOut] )`
  
- `group.attr("x", function(d,i){`
  - `return xscale(d.size);``})`
  
- $y = mx + b$



---

# Min and Max

But how do you figure out the min and max for the domain?

---

# D3

A really powerful for-loop with a ton of useful helper functions

---

# Min and Max

- `d3.min( [ ] )` → number
- `d3.max( [ ] )` → number
- `d3.extent( [ ] )` → [number,number]

---

## Min and Max

- `d3.min( [ ] )` → number
- `d3.max( [ ] )` → number
- `d3.extent( [ ] )` → [number,number]
  
- All can be combined with
  - `.map( function(d){ } )`, which returns an [ ]

---

```
d3.min(  
  data.map( function(d){ return d.age; })  
) // returns the minimum age
```

---

# Linear Scales

- You can even keep the same scale, and just update the domain and/or range as necessary
- Note: This will not *update* the graphics all on its own

---

# Ordinal Scales

- D3 has built-in color scales!
  - (And they're easy!)
  
- `var colorscale = d3.scale.category10( )`
  
- Also available are:
  - `category20( )`
  - `category20b( )`
  - `category20c( )`
  - (and even a few more)

---

# Ordinal Nominal Scales

- D3 has built-in color scales!
  - (And they're easy!)
  
- `var colorscale = d3.scale.category10( )`
  
- Also available are:
  - `category20( )`
  - `category20b( )`
  - `category20c( )`
  - (and even a few more)



---

## Ordinal Nominal Scales

- [ {type:'Bird'}, {type:'Rodent'}, {type:'Bird'} ]
- var colorscale = d3.scale.category10( )
- .attr("fill",function(d,i){
  - return colorscale(d.type)})
  - <rect fill="blue"></rect>
  - <rect fill="orange"></rect>
  - <rect fill="blue"></rect>

---

# Axes

D3 also has *visual* helper-functions

---

## Axes

- `yaxisglyph = chart.append("g")`

```
yaxis = d3.svg.axis( )
```

```
  .scale( yscale ) //must be a numerical scale
```

```
  .orient( 'left' ) //or 'right' or 'top' or 'bottom'
```

```
  .ticks( 6 ) //number of ticks, default is 10
```

```
yaxisglyph.call(yaxis)
```

---

D3 even has some  
entire techniques built in...

<http://bl.ocks.org/mbostock/4062045>

---

What if the data is changing?

---

## E-U-E Pattern Template

```
var group = vis.selectAll("rect")
    .data(rawdata) //rawdata must be an array!
group.enter().append("svg:rect") //ENTER!
    .attr()
    .attr()
group //UPDATE!
    .attr()
    .attr()
group.exit().remove() //EXIT!
```

---

# E-U-E Pattern Template

```
function redraw(rawdata){
  var group = vis.selectAll("rect")
    .data(rawdata) //rawdata must be an array!
  group.enter( ).append("svg:rect") //ENTER!
    .attr( )
    .attr( )
  group //UPDATE!
    .attr( )
    .attr( )
  group.exit( ).remove( ) //EXIT!
}
```

---

# E-U-E Pattern Template

```
function redraw(rawdata){
  var group = vis.selectAll("rect")
    .data(rawdata) //rawdata must be an array!
  group.enter().append("svg:rect") //ENTER!
    .attr( )
    .attr( )

  group.transition() //UPDATE!
    .attr( )
    .attr( )
  group.exit().remove() //EXIT!
}
```



---

# Transitions

- CSS3 transitions with D3 are *magical!*
- D3 interpolates values for you...

---

# Transitions

```
rect.attr("height", 0)
```

```
rect.transition( )
```

```
.delay( 500 ) //can be a function of data
```

```
.duration(200) //can be a function of data
```

```
.attr("height", 5)
```

---

So they're no longer static...

But they're not really interactive...

---

# Interaction

## The on( ) Method

---

.on( )

```
rect.on ("click", function(d){  
    d.color = "blue";  
    redraw( )  
})
```

## HTML Events

- click
- mouseover
- mouseenter
- mouseout
- etc.

---

## Where to get learn more...

- <http://d3js.org/>
  - Tons of examples and basics.
- <https://github.com/mbostock/d3/wiki/API-Reference>
  - Official D3 documentation. Extremely well done.
- <https://github.com/mbostock/d3/wiki/Tutorials>
  - List of seemingly ALL the tutorials online
- The Google/StackOverflow combination
  - (my personal favorite)

---

Thanks!

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Questions?



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