Lab 9 | D3

What happened to Lab 8, the “advanced Open Layers” one? It was… eliminated. Basically, two-part Lab 5 was worth twice as much as a typical lab, and my secret plan was to allow you all to drop your worst score on one of the other labs OR let you take extra credit for it. However, with the unexpected elimination of classes that week before spring break, we’re now short one week and so we are back to just 9 labs and no bonus assignment. But 10 labs if you count 5.1 and 5.2 separately. Which I am doing now. So the labs are still worth 400 points total and literally nothing has changed except you have one fewer assignment. Stop questioning my lesson planning and read on.

This lab introduces D3.js. This stands for “Data Driven Documents.” From their website:

D3.js is a JavaScript library for manipulating documents based on data. D3 helps you bring data to life using HTML, SVG, and CSS. D3’s emphasis on web standards gives you the full capabilities of modern browsers without tying yourself to a proprietary framework, combining powerful visualization components and a data-driven approach to DOM manipulation

Notably, D3 is not exclusively intended for mapping. But it is quite a popular framework for web-based visualizations, and naturally people wanted to make maps with it, so the developers have added all kinds of support for mapping. This is good, but potentially a little challenging: It’s good because you’ll find TONS of examples on the web if you want to take the next steps and develop your final project (or some sort of more advanced interactive map) with this platform. You certainly can make some very complex mapping applications with it! It’s slightly more challenging because it isn’t like the other mapping APIs we’ve encountered, where the library is clearly designed to recognize and work with spatial data and has simplified functions built in. So while you could make a very simple interactive map with OpenLayers or Leaflet or ArcGIS API using just a few lines of code, you have to do a little more code cobbling here to get an equivalent application. You’ll see what I mean as we move through the following steps. Considering that many of you have expressed deep concerns about the complexity of previous assignments, and given that we cannot meet physically to work through issues, I am keeping this assignment very simple. On Thursdays, I will propose additional challenges for students who would like to try developing advanced features to extend the week’s lesson. Successfully completing those challenges will be worth additional extra credit points.

Please read the instructions carefully and do not simply copy and paste the code segments chronologically into a document and then ask me why it is not working. While you are *welcome* to copy code fragments directly out of this instructional document, you must ensure that you are putting them in their proper location and not duplicating any of the same sections. Finally, publish your work to your GitHub Pages site as usual and submit to me through Canvas the URL to your *completed* work on your GitHub page.

Set up the Basics: A Street Map of Northeast Lincoln

Open a new blank page in your text editor. Let us begin with a simple HTML file. Begin with the standard opening/closing HTML tags, head tags, and body tags.

- First, in the head, we give our document a title “Lab 9 | D3” and we also link out to the D3 library so that we can use features and functions from it.
- Also, create script tags within the body section, we’ll be adding our D3 code there!

```
<!DOCTYPE html>
<html>
   <head>
    <title>Lab 9 | D3</title>

    <script src="https://d3js.org/d3.v5.min.js" charset="utf-8"></script>
   </head>

    <body>

        <script>
          //we will be putting our D3 code here within body script tags

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

- Next, **in the body’s `<script>` section**, we’ll need to define the basic parameters of the map – how much room this graphic element should take up

on the screen. We do this by adding variables to define the width and the height. We will append these attributes to our “SVG” (scalable vector graphic) canvas

- Essentially, we’re telling D3 that we want to create a graphical element in our page, and we want to set the “width” to our variable width, “height” to our variable “height”

- Finally, we’ll tell D3 that we want to include geometry (appending “g” to our SVG set), and we’ll use a variable called g to do this. Notably, this is just creating EMPTY geometry, because we haven’t actually appended any data to it, yet. Just like we appended attributes to “svg” to set its definitions, we will need to eventually do this same with our data once we add it.

```
//width and height of the visualization
  var width = 1000;
  var height = 600;

//create the SVG
  var svg = d3.select( “body” )
  .append( “svg” )
  .attr( “width”, width )
  .attr( “height”, height );

// Append empty placeholder g element to the SVG
// g will contain geometry elements
var g = svg.append( "g" );
```

- Although D3 doesn’t natively understand a lot of GIS data, it can turn GeoJSON data into screen coordinates if it knows which projection to use for drawing these data. It has a handful of built-in projections, and there are plugins available for a wider variety of options. So you’re not just stuck with Web Mercator! Yay!

- Let’s set it to use an Albers conic projection – just because. Albers is one of the projections that doesn’t require a special plugin, so we can call it up by using d3.geoAlbers() [see below]

- First, we create a variable for the projection and we want to center it on northeast Lincoln. Put this below the width and height definitions:

```
// Width and Height of the whole visualization
// Set Projection Parameters
var albersProjection = d3.geoAlbers()
    .scale( 2850000 )
    .rotate( [96.6327,0] )
    .center( [0, 40.8497493] )
    .translate( [width/2,height/2] );
```

    - Scale sets the scale of the map (in a frustrating opposition to all things mapping/GIS, smaller numbers are actually larger scales, so 1 is the smallest.
    - Rotate sets the longitude of origin for the projection
    - Center sets the standard parallel (latitude) – so you use rotate and center together to "center" the map
    - Finally, translate is just a pixel offset, usually to ensure that the projection center aligns with the viewing area you want. *Just use the code I've provided for this*.

- Finally, we need to set up something called a "path generator" or "Geo Path." In D3, we use d3.geoPath to display data – this is a function that looks to the latitude/longitude coordinates from a GeoJSON feature and then changes them into screen coordinates based on the projections you set (*for those interested: the more technical explanation here is that the "d" attribute of an SVG path element, which D3 uses for generating shapes, needs a particular type of data string before it can draw shapes, and this process algorithmically calculates a suitable data string and returns the feature objects as a series of vector drawings*)

- Because we already have a projection picked out and identified, declaring the "Geo Path" is quite simple. We just create a variable and then assign it the projection parameters we've already defined above:

```
var geoPath = d3.geoPath()
    .projection( albersProjection );
```

Adding your layers

Now that you have the projection defined and all of your basic settings arranged, it is time to load in the data layers. But first, *confirm that you're caught up*. The script in your **body** section should look something like this:

```
<script>
var width = 1000;
var height = 600;

// Create SVG
var svg = d3.select( "body" )
    .append( "svg" )
    .attr( "width", width )
    .attr( "height", height );

// g will contain geometry elements
var g = svg.append( "g" );


// Width and Height of the whole visualization
// Set Projection Parameters
var albersProjection = d3.geoAlbers()
    .scale( 2850000 )
    .rotate( [96.6327,0] )
    .center( [0, 40.8497493] )
    .translate( [width/2,height/2] );

// Create GeoPath function to turn lat/lon into screen coordinates
var geoPath = d3.geoPath()
    .projection( albersProjection );

</script>
```

NOW, for data, we'll use GeoJson layers *stored as variables in .JS files*. Because we aren't able to meet in person to troubleshoot potential conversion issues, I'm just providing these files to you from my site. You load in these files just like you have in the previous assignments – by adding a script in the head with a link to each file.

- Add a new script tag and link to my roads file:
  https://rshepard2.github.io/Lab9/data/lnkrds.js

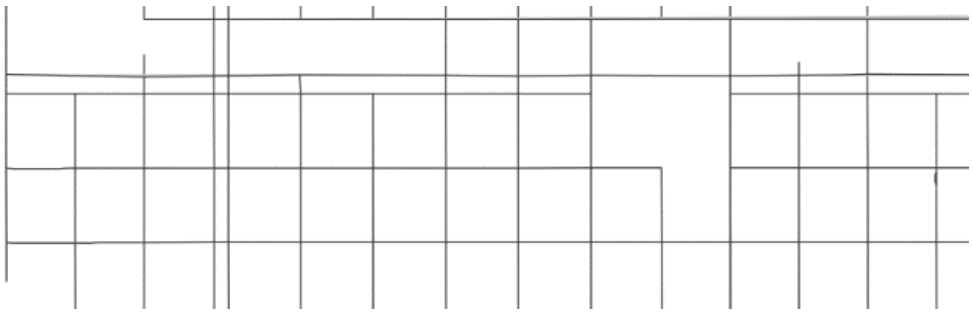
  (It should look like this in your head section):
  <script src="https://rshepard2.github.io/Lab9/data/lnkrds.js"></script>

  If you click through to view the file I've provided, you will notice that the data are all already assigned to a variable, var lnkrds. Once you've added the script into your HTML file, you can use this variable just the same as if you wrote it all into your code.

- In D3, we need to "bind" the data layer to our geometry or "g" element in order to get it to draw on the page. We do this by selecting and connecting to the features, appending them to the geo paths, then also defining the draw attributes (fill, colors, stroke color. Put this after your geopath variable section. It will look like this:

```
//select element; bind data; append attributes; apply
g.selectAll( "path" )
    .data( lnkrds.features )
    .enter()
    .append( "path" )
    .attr( "fill", "#ccc" )
    .attr( "stroke", "#333")
    .attr( "d", geoPath );
```

At this point, you should be able to save and run (by opening with a web browser or double-clicking the HTML file in your directory to open a browswer) your code to get a map. You'll see basic street lines with some strange gray areas (which are actually related to some topological issues from my roads dataset. Don't worry about it). It will just look, roughly, like this:



- Now that you've gone through the steps for adding a data layer, adding another layer is quite simple!

- For adding the second layer, we again just need to load in a .js file with GeoJson in it. Again, in the interest of time and simplicity, we'll just work from my own stash once again.

- Into the head section, add a link to my (heavily simplified) building shapefile layer. This is a GeoJson file of a bunch of residences:
    - https://rshepard2.github.io/Lab9/data/northeast_lnk_blds.js

  Remember, you want to add ***<script src="*** *and then the link, and then* ***"></script>*** *just as you did above. I didn't write this out because I want you to be familiar with this process rather than just copying from the instructions.*

  You'll notice that I'm calling the variable (in the JS file) "lnkbldngsjson"

- SO, after you've linked out to the data to bring it into your HTML document, you again need to return to the script in the body, below your roads data definitions, and once again go through the process of identifying, selecting, and defining *how* you want those features to draw in your D3 geometry ("g"). This time, I'm also going to introduce a variable to "append" the buildings data to my list of geometry. I'm doing this because it's good practice, but also because I'm going to want to customize some user interactions on that layer specifically! First, add it:

```
var lnk_json = svg.append( "g" );

lnk_json.selectAll( "path" )
       .data( lnkbldngsjson.features )
       .enter()
       .append( "path" )
       .attr( "fill", "#900" )
       .attr( "stroke", "#999" )
       .attr( "d", geoPath );
```

Notice here that your variable name you use to refer to the dataset in your HTML document (here I use "lnk_json") does NOT have to match the GeoJSON variable name (which is "lnkbldngsjson") in the linked data file. HOWEVER, when you actually define the data for stylizing with D3 (in the

.data part), you DO need to use the variable name that is used in your file. I chose two different names here to highlight this potential source of confusion.

Now at this point you'd have two different layers. Red buildings and gray streets, but they're not yet interactive for a prospective user – it's just a static map. And as you know, web GIS is all about embracing the power of interactive mapping. There are potentially endless things you could do here, but I'll first introduce an interactive component that we've not yet used in previous labs, the "hover over." It's like a pop-up, but it is a user-triggered event that happens whenever a user's cursor hovers over a feature. In D3, as in most APIs, you can specify which layers are susceptible to this sort of event.

We will assign a hover over effect for the buildings layer only, so that users can see what year a house was built when they hover the cursor over a building footprint.

To do this, we FIRST create a class called "building data," and we tell D3 to populate this from the "RESYRBLT" field in the JSON data. If you are paying close attention to the code snippet, you'll also see that we're telling the script to put the data field into the text of "h2," an element on the page we haven't yet defined. Typically this is a "headline 2" page element, a subtitle, which should be larger than typical text but not the largest thing on a page. SO, **add the following script to your lnk_json section, just below the .attr("d", geoPath);** - *and make sure to eliminate the existing semicolon after .attr("d", geoPath); See further down to confirm you have done this properly*

```
.attr("class","buildingdata")
.on("mouseover", function(d){

//populate h2 with "built in" & the year built field from the json

d3.select("h2").text("Built in " + d.properties.RESYRBLT);
       d3.select(this).attr("class","buildingdata hover");
       })

//here, D3 to replace text interactively based on building data
       .on("mouseout", function(d){
              d3.select("h2").text("");
              d3.select(this).attr("class","buildingdata");
       });</script>
```

- Finally, even though we've added interactivity to the mapped area, we still need to set these styles in the head (for example, the H2 element is not yet defined anywhere in our code, so the hover over is writing to an object that we haven't even created). You can create styles with standalone CSS pages, or you can define the styles in the head. We are going to do the latter here to keep things simple.
- Put this style into the head section -

```
<style>
body {
    position: absolute;
    font-family: "Proxima Nova", "Montserrat", sans-serif;
}
h1, h2 {
    position: absolute;
    background: white;
    left: 10px;
    font-size: 1.3em;
    font-weight: 100;
}
h2 {
    top: 30px;
    font-size: 1em;
}
.hover {
    fill: yellow;
}
</style>
```

- Then, follow up in the BODY section with an actual H2 section so that this text can GO somewhere in the map. Put this right after the BODY tag -

```
<h1>Age of Northeast Lincoln Homes</h1>
    <h2></h2>
```

Ultimately, not including the style tag text and the lines immediately above (defining where the H2 section goes), your Lincoln building section should now look like this (*new addition from last page is in darker text)* -

```
var lnk_json = svg.append( "g" );

lnk_json.selectAll( "path" )
       .data( lnkbldngsjson.features )
       .enter()
       .append( "path" )
       .attr( "fill", "#900" )
       .attr( "stroke", "#999" )
       .attr( "d", geoPath )
       .attr("class","buildingdata")
.on("mouseover", function(d){

//populate h2 with "built in" & the year built field from the json

d3.select("h2").text("Built in " + d.properties.RESYRBLT);
       d3.select(this).attr("class","buildingdata hover");
       })
//here, D3 to replace text interactively based on building data
       .on("mouseout", function(d){
              d3.select("h2").text("");
              d3.select(this).attr("class","buildingdata");
       });
```

This section basically just says D3 should populate the subtitle H2 with information taken from the RESYRBLT field, when a user hovers over an object in the buildings layer. It also defines what to do when users move off an object (mouseout), which is to set it all back to blank *d3.select("h2").text(" ");*

Colorizing the Buildings – an Interactive Choropleth

- Now we will apply some sort of color style to all the buildings, based on the year of construction as well.
- To do this, we will tell D3 that we want to use a color ramp based on the RESYRBLT field that we've used to populate the hover over. This shows us that the same variable in the GeoJSON layer can be used to stylize objects as well as populate hover over effects (or pop ups).
- The first step here is determining what colors to use. Instead of determining breaks, we will just pick a "high color" and a "low color" for this ramp and let D3 determine the colors in between. We'll make a range from a very light pink hex `f9f9f9` to a strong raspberry color `bc2a66` to keep it in the same

spectrum. We first add these hex colors as variables. Put this below the var width and var height declarations, within the script but near the top:

```
var lowColor = '#f9f9f9'
var highColor = '#bc2a66’
```

- Then we will need to tell D3 what the minimum and maximum VALUES are for this ramp, also declaring these as variables. Remember that we’re using years, so we don’t put these in quotes, these are numbers. Put these variables anywhere in the BODY script. I just put them at the top with the others to keep the primary variables organized.

```
var minVal = 1900
var maxVal = 2020
```

- Now, just below these, we’ll define the color ramp. You’re drawing here on D3’s ability to create a “linear scale” based on values, and we’re using the values (and colors) we just set to define that range:

```
var ramp = d3.scaleLinear().domain([minVal,maxVal]).range([lowColor,highColor]);
```

We just need to make one final change: we’ve got to go back to the attributes of the buildings layer and change the “fill” pattern.

- Find this section of code where you defined the color of the buildings:

```
lnk_json.selectAll( "path" )
       .data( lnkbldngsjson.features )
       .enter()
       .append( "path" )
       .attr( "fill", "#900" )
       .attr( "stroke", "#999" )
```

- We don’t want it all to be set to hex color #900, we want that color to come in dynamically from our dataset instead, based on the color ramp we created.
- We rewrite this line to draw upon the ramp, using the RESYRBLT field from our dataset to pick colors from that within the range of the color ramp:

```
lnk_json.selectAll( "path" )
   .data( lnkbldngsjson.features )
   .enter()
   .append( "path" )
   .attr( "fill", function(d) { return ramp(d.properties.RESYRBLT) })
  .attr( "stroke", "#999" )
```

Now save the HTML file and upload to your GitHub page.

Submitting Your Assignment

- Send me your URL in a text file or word document, through Canvas.