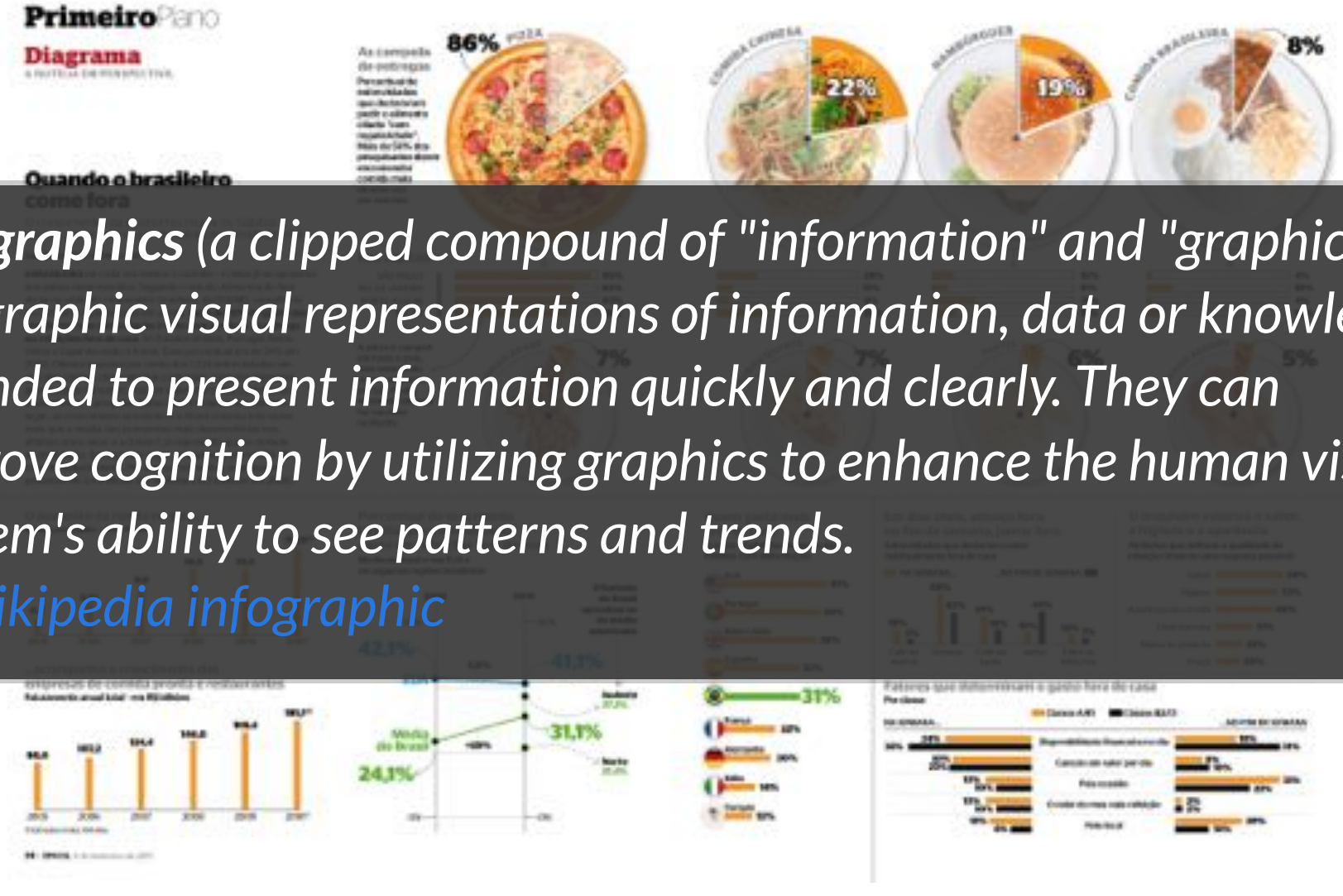
DSCI 554 LECTURE 3

DESIGN SPACE OF VISUALIZATIONS, GRAPHING IN THE BROWSER, INTRODUCTION TO D3

Dr. Luciano Nocera

OUTLINE

- Design space and design trade-offs
- Graphing in the browser
- Introduction to D3
- Quiz questions

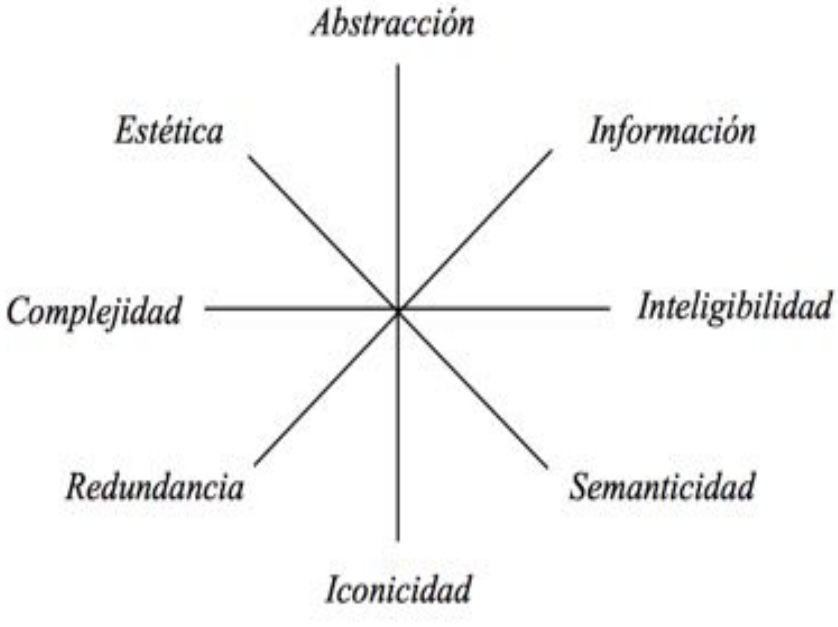


Infographics *(a clipped compound of "information" and "graphics") are graphic visual representations of information, data or knowledge intended to present information quickly and clearly. They can improve cognition by utilizing graphics to enhance the human visual system's ability to see patterns and trends.*

-- Wikipedia infographic

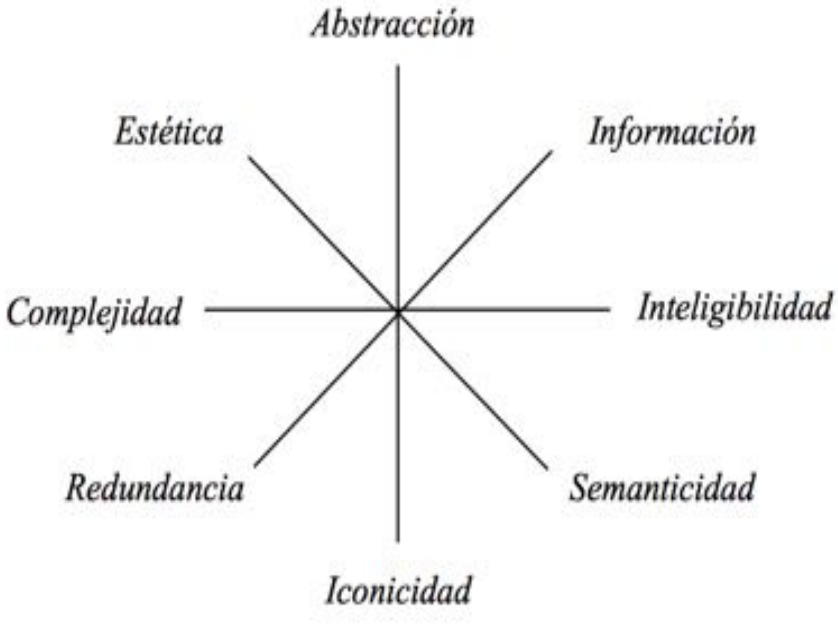
<image>

Design Space [Costa 1998]



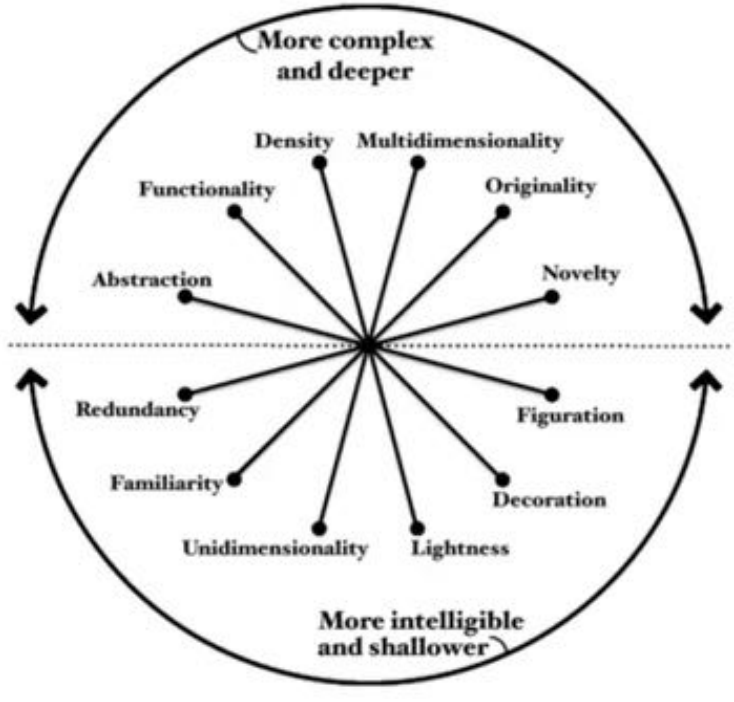
La esquemática: visualizar la información, Joan Costa Solà-Segalés, 1998.

Design Space [Costa 1998]



La esquemática: visualizar la información, Joan Costa Solà-Segalés, 1998.

Visualization Wheel [Cairo 2012]



Cairo, Alberto. The Functional Art: An introduction to information graphics and visualization. 2012.

Less complex → More complex

FIGURATION-ABSTRACTION

Measures the distance from referent to the representation

DECORATION-FUNCTIONALITY

Measures the amount of informative content

LIGHTNESS-DENSITY

Measures the amount of content displayed in relation to space

---

UNIDIMENSIONALITY-MULTIDIMENSIONALITY

Measures the number of layers and forms used to encode the data

---

FAMILIARITY-ORIGINALITY

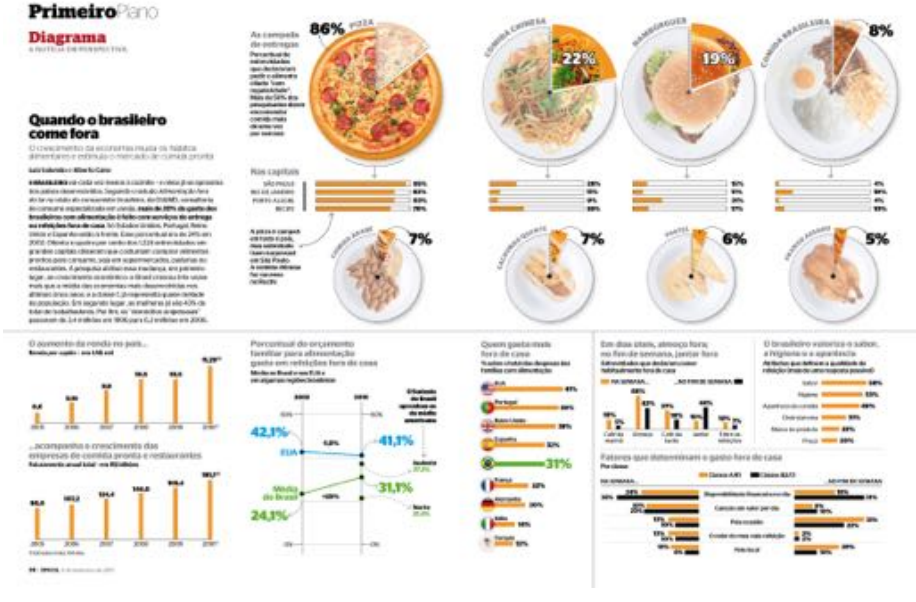
Measures how challenging the forms are for the user to understand

---

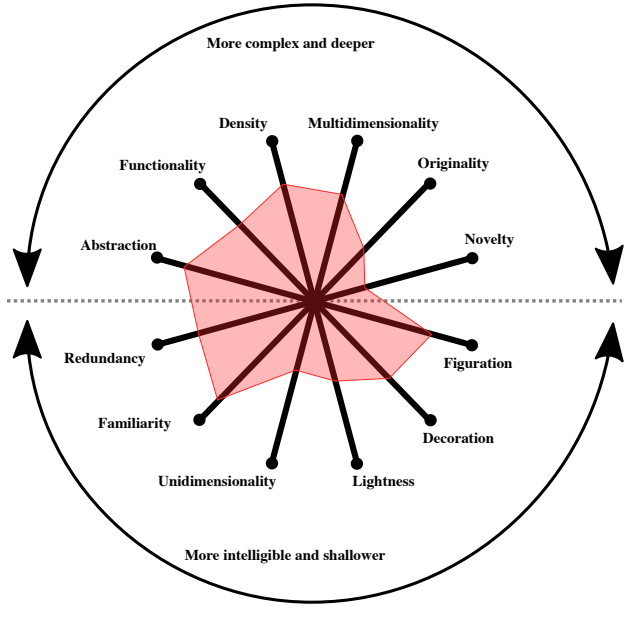
REDUNDANCY-NOVELTY

Measures the number of times things are explained

USING THE VISUALIZATION WHEEL



Infographic



Corresponding visualization wheel.

OUTLINE

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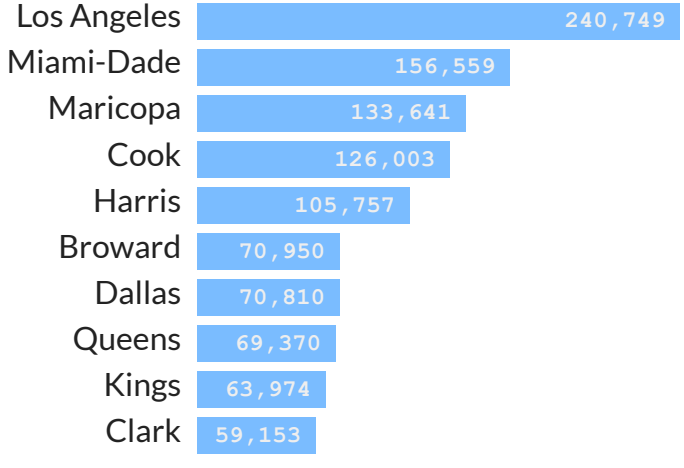
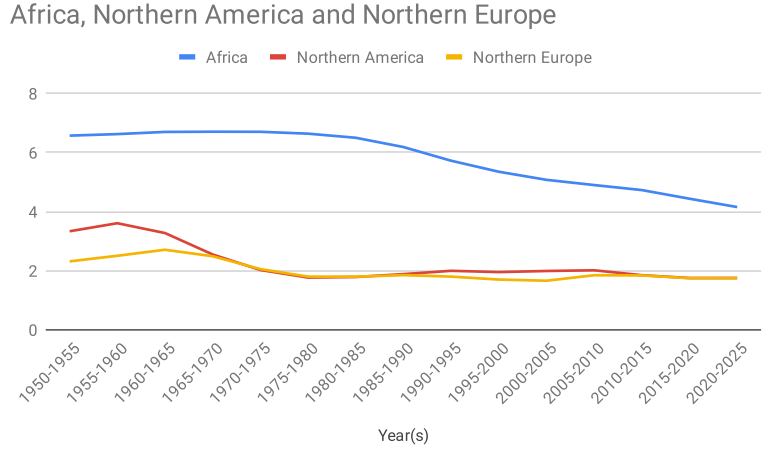
2D GRAPHICS IN THE WEB

Top 10 COVID-19 confirmed in US, Aug 31 2020 (source Johns Hopkins University)



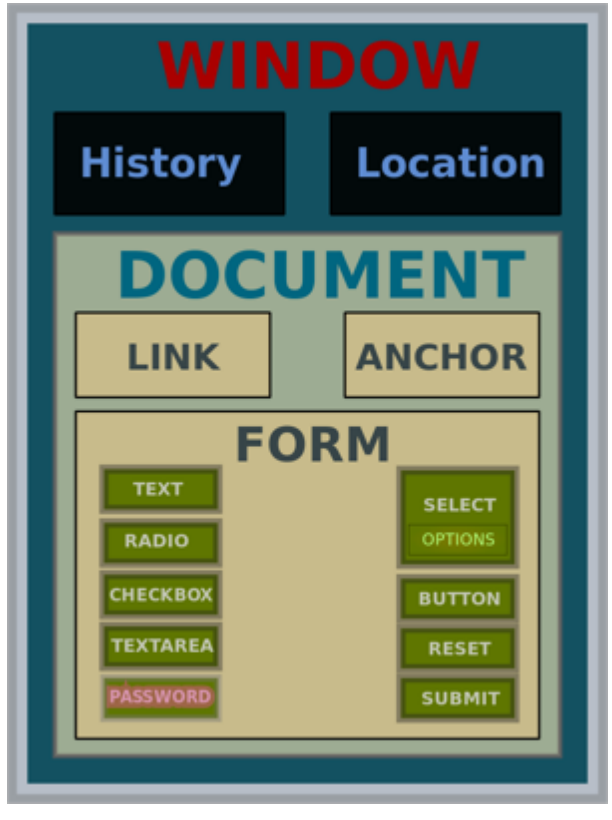
Bar chart built with HTML `div`



Multi-line chart built with SVG elements

DOCUMENT OBJECT MODEL (DOM)

- Used in browsers for HTML documents
- Implemented as *"Javascript object"*
- In the DOM everything is a node:
  - The document is the *document node*
  - HTML elements are *element nodes*
  - HTML attributes are *attribute nodes*
  - Inner HTML text is a *text node*
  - Comments are *comment nodes*

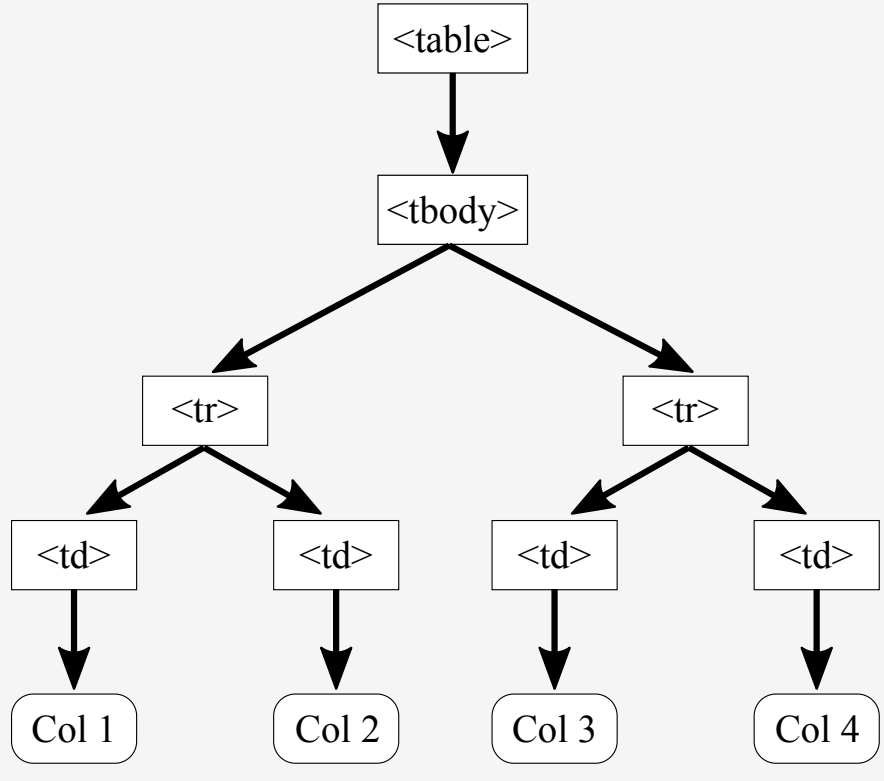


Hierarchical box model (conceptual data model)

DOM EXAMPLE

```
<TABLE>
  <TBODY>
  <TR>
    <TD>Col 1</TD>
    <TD>Col 2</TD>
  </TR>
  <TR>
    <TD>Col 3</TD>
    <TD>Col 4</TD>
  </TR>
  </TBODY>
</TABLE>
```

HTML table



Corresponding DOM Tree of HTML table

APPEARANCE: CSS BOX MODEL

Everything in CSS has a box around it

2 types of boxes:

- Inline: occupy the space bounded by the tag
- Block: start on new line and take the full width

Box type controlled by the `display` property

```
display: [inline|block]
```

```
span is <span>inline</span>
```

span is inline

```
div is <div>block</div>
```

div is

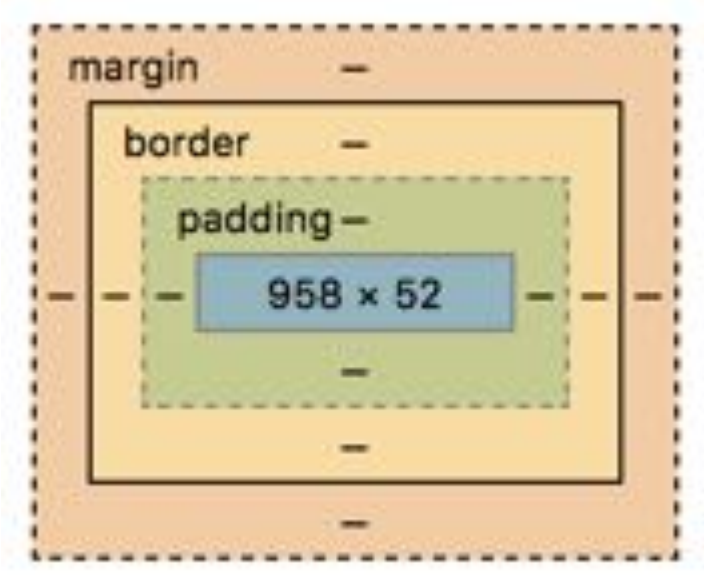
block

```
div as <div style="display:inline">inline</div>
```

div as inline

BOX MODEL PARAMETERS

Margins: space around an element
Border: border around an element
Padding: space within an element




```
padding: 1px; /* apply to all four sides */
padding: 5% 10%; /* vertical | horizontal */
padding: 1px 2px 2px; /* top | horizontal | bottom */
padding: 5px 1px 0 2px; /* top | right | bottom | left */

border: 1px solid red; /* width | style | color */

margin: 1px; /* apply to all four sides */
margin: 5% auto; /* vertical | horizontal */
margin: 1px auto 2px; /* top | horizontal | bottom */
margin: 2px 1px 0 auto; /* top | right | bottom | left */
```

Specifying padding, border and margin with CSS

HTML ELEMENTS ATTRIBUTES

GLOBAL ATTRIBUTES

- `id`: use to reference unique containers
- `class`: use to apply common styles
- `style`: use to style specific elements

```
<div id="chart1"></div>
<svg id="chart2"></svg>

<style>
  div.bar { background-color: red; }
  circle.dot { fill: red; }
</style>

<div class="bar">bar 1</div>

<svg style="background-color: lightpink">
  <circle class="dot" cx="5" cy="5" r="2"/>
</svg>
```

ELEMENT SPECIFIC ATTRIBUTES

Use to place and size elements

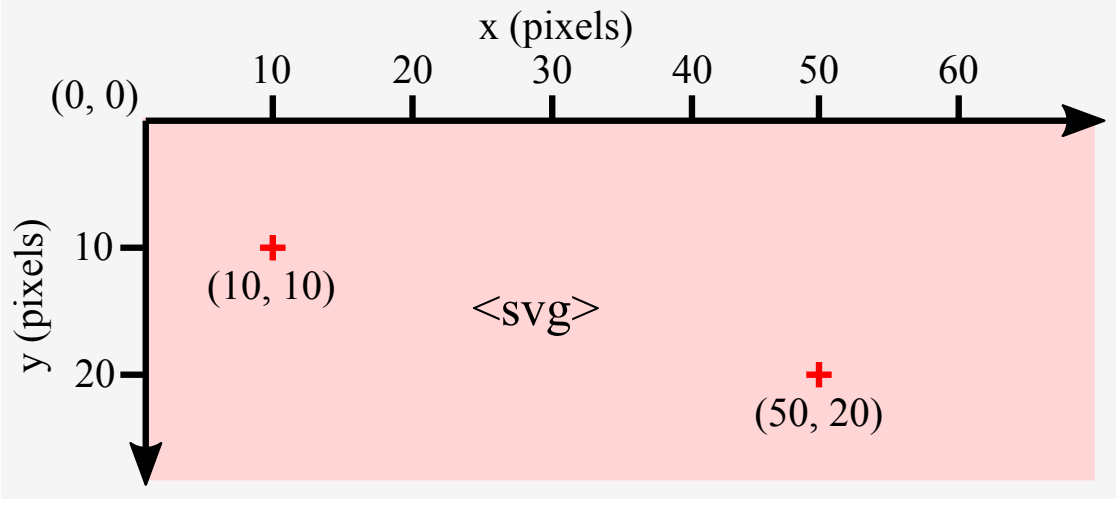
```
<img src="pict.png" width="20px"\>

<svg>
  <circle cx="5" cy="5" r="2"/>
</svg>
```

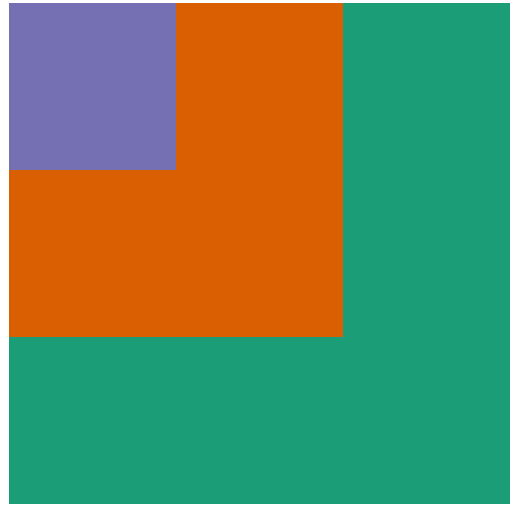
CSS INHERITANCE

- CSS properties are inherited by descendants
- Use `style` to customize individual elements
- Use `class` as a short hand for common descendants properties

```
<style>
  .redbar {
    background-color: red;
    height: 30px;
    margin-bottom: 5px;
  }
</style>

<div style="font-size: 0.5em; font-weight: bolder;">
  <div class="redbar" style="width: 100px;">bar1</div>
  <div class="redbar" style="width: 200px;">bar2</div>
</div>
```

SVG





- SVG elements are drawn in the <svg>
- Coordinate system in pixels starting up left corner of <svg>
- Painter's algorithm defines drawing order:
  coding order is drawing order (last drawn on top)

HTML VS. SVG FOR CHARTING

	HTML	SVG
Placement & sizing	CSS box model relative/absolute placement	Cartesian coordinate system and viewport
Primitives	CSS box model boxes	Named shapes, curves
Text	inner HTML	<text>
Drawing order	CSS box model / DOM order	Painter's algorithm coding order → depth order
Hierarchy	CSS box model	Nesting using <g>

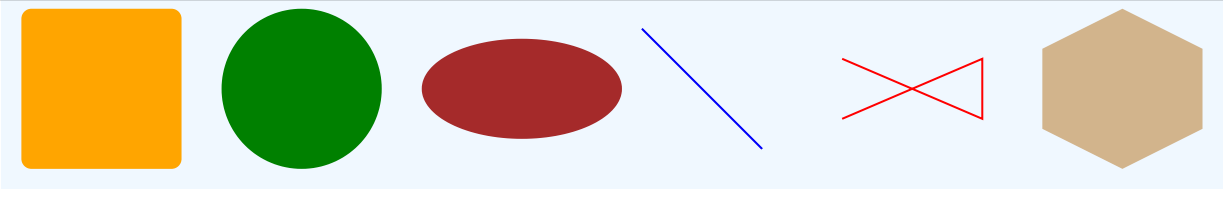
simpler for graphing

BASIC SVG SHAPES & ATTRIBUTES

Basic SVG shapes (`rect circle ellipse line polyline polygon`) have attributes to control:

- Positions & size
- Fill (interior color)
- Stroke (border color)

```
<rect x="10" y="10" width="80" height="80" rx="5" ry="5" fill="orange"/>

<circle cx="150" cy="50" r="40" fill="green"/>

<ellipse cx="260" cy="50" rx="50" ry="25" fill="brown"/>

<line x1="320" y1="20" x2="380" y2="80" stroke="blue"/>

<polyline points="420,35 490,65 490,35 420,65" stroke="red" fill="none"/> <!-- open -->

<polygon points="560,10 600,30 600,70 560,90 520,70 520,30" fill="tan"/> <!-- closed -->
```

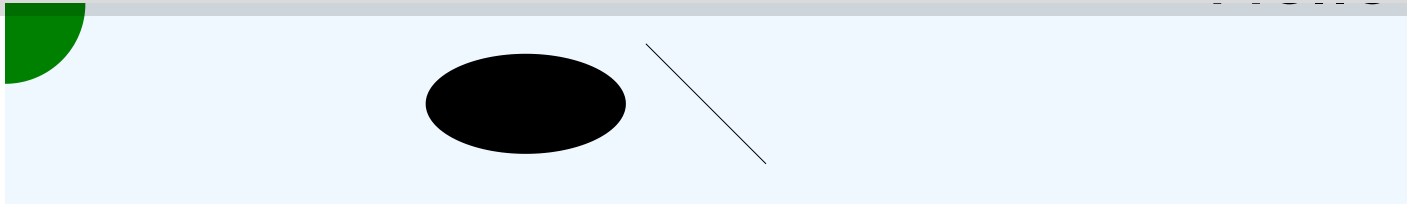


W3C Scalable Vector Graphics (SVG) 1.1 (Second Edition)

ATTRIBUTES DEFAULTS

- Positions & size (e.g., x, y, x1, y1, x2, y2, cx, cy, width, height, r, rx, ry) defaults to *"0"*
- Fill defaults to *"black"* for shapes and *"none"* for text
- Stroke defaults to *"none"*

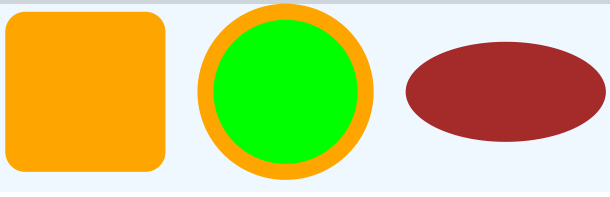
```
<rect x="10" y="10" idth="80" height="80" rx="5" ry="5" fill="orange"/> <!-- width="0" -->

<circle x="150" y="50" r="40" fill="green"/> <!-- cx="0" cy="0"-->

<ellipse cx="260" cy="50" rx="50" ry="25" background-color="brown"/> <!-- fill="black" -->

<line x1="320" y1="20" x2="380" y2="80" color="red"/> <!-- stroke="none" -->

<polyline points="420,35 490,65 490,35 420,65" stroke="myred" fill="none"/> <!-- stroke="none" -->

<polygon oints="560,10 600,30 600,70 560,90 520,70 520,30" fill="tan"/> <!-- points="" -->

<text x="600">Hello</text> <!-- text element requires a y, here y="none" -->
```



SVG STYLING PROPERTIES

MOST BUT NOT ALL SVG attributes have CSS styling properties

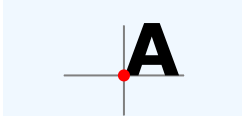
```
<svg>
  <!-- these work -->

  <rect style="x: 10; y: 10; width: 80; height: 80; rx: 5; ry: 5; fill: orange;"/> <!-- rx, ry now works! -->

  <circle style="cx: 150; cy: 50; r: 40; fill: lime; stroke:orange; stroke-width: 8px;"/>

  <ellipse style="cx: 260; cy: 50; rx: 50; ry: 25; fill: brown;"/> <!-- rx, ry now works! -->

  <!-- these don't work! -->

  <line style="x1: 320; y1: 20; x2: 380; y2: 80; stroke: blue;"/> <!-- x1, x2, y1, y2 = 0 -->

  <polyline style="points: 420,35 490,65 490,35 420,65; stroke: red; fill: none;"/> <!-- points = '' -->

  <polygon style="points: 560,10 600,30 600,70 560,90 520,70 520,30; fill: tan;"/> <!-- points = '' -->
</svg>
```



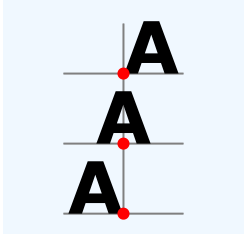
SVG TEXT POSITIONING

```
<svg>
 <text x="0" y="70" style="text-anchor: start; alignment-baseline: unset;">Text0<text/>
</svg>
```

`x, y` define where the text is placed in the SVG: defaults to the text bottom left



text-anchor controls the horizontal placement of the text relative to `x, y`



`text-anchor: start` ← default

`text-anchor: middle`

`text-anchor: end`

alignment-baseline controls the vertical placement of the text relative to `x, y`

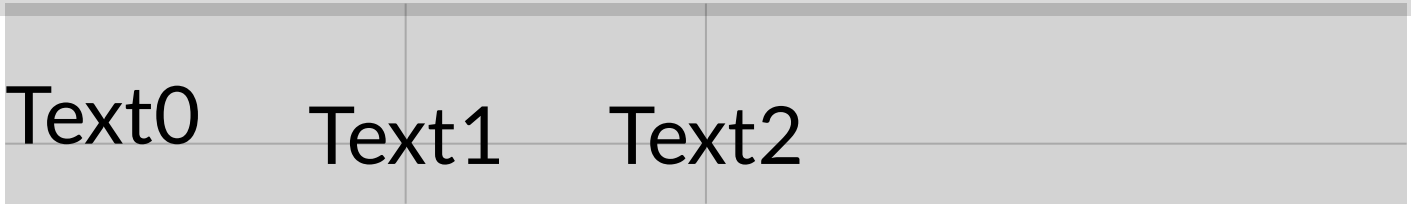
`alignment-baseline: hanging`

`alignment-baseline: middle`

`alignment-baseline: unset` ← default

HOW TO CENTER SVG TEXT

```
<svg>
  <text x="0" y="70">Text0<text/>
  <text x="200" y="70" text-anchor="middle" alignment-baseline="middle">Text1<text/>
  <text x="350" y="70" style="text-anchor: middle; alignment-baseline: middle;">Text2<text/>
</svg>
```



OUTLINE

- Design space and design trade-offs
- Graphing in the browser
- Introduction to D3
- Quiz questions

```
// https://d3js.org Version 5.5.0. Copyright 2018 Mike Bostock.
(function(t,n){"object"==typeof exports&&"undefined"!=typeof module?
n(exports):"function"==typeof define&&define.amd?
define(["exports"],n):n(t.d3=t.d3||{})})(this,function(t){"use strict";function
n(t,n){return t<n?-1:t>n?1:t>=n?0:NaN}function e(t){return 1===t.length&&
(t=function(t){return function(e,r){return n(t(e),r)}}(t)),
{left:function(n,e,r,i){for(null==r&&(r=0),null==i&&(i=n.length);r<i;){var
o=r+i>>>1;t(n[o],e)<0?r=o+1:i=o}return r},right:function(n,e,r,i){for(null==r&&
(r=0),null==i&&(i=n.length);r<i;){var o=r+i>>>1;t(n[o],e)>0?i=o:r=o+1}return
r}}}function r(t,n){return[t,n]}function i(t){return null===t?NaN:+t}function
o(t,n){var
e,r,o=t.length,a=0,u=-1,f=0,c=0;if(null==n)for(;++u<o;)isNaN(e=i(t[u]))||(c+=
(r=e-f)*(e-(f+=r/++a)));else for(;++u<o;)isNaN(e=i(n(t[u],u,t)))||(c+=(r=e-f)*
(e-(f+=r/++a)));if(a>1)return c/(a-1)}function a(t,n){var e=o(t,n);return e?
Math.sqrt(e):e}function u(t,n){var e,r,i,o=t.length,a=-1;if(null==n)
{for(;++a<o;)if(null!=(e=t[a])&&e>=e)for(r=i=e;++a<o;)null!=(e=t[a])&&(r>e&&
(r=e),i<e&&(i=e))}else for(;++a<o;)if(null!=
(e=n(t[a],a,t))&&e>=e)for(r=i=e;++a<o;)null!=(e=n(t[a],a,t))&&(r>e&&(r=e),i<e&&
(i=e));return[r,i]}function f(t){return function(){return t}}function c(t)
{return t}function s(t,n,e){t=+t,n=+n,e=(i=arguments.length)<2?(n=t,t=0,1):i<3?
1:+e;for(var r=-1,i=0|Math.max(0,Math.ceil((n-t)/e)),o=new
Array(i);++r<i;)o[r]=t+r*e;return o}function l(t,n,e){var
r,i,o,a,u=-1;if(n=+n,t=+t,e=+e,t===n&&e>0)return[t];if((r=n<t)&&
(i=t,t=n,n=i),0===(a=h(t,n,e))|...
```

Immediately-Invoked Function Expression (IIFE) signature: `(function() {})();`

D3

TL;DR. *JavaScript library to bind data to the DOM, i.e., vocabulary of graphical marks come directly from web standards: HTML, SVG, and CSS.*

Generate graphic:

1. *Get the data formatted as an array*
2. *Use D3 to map the data to HTML elements*
3. *Let the browser render*

Two ways to map data to HTML elements with D3:

1. *Select & append*
2. *Data join*

ABOUT D3

- Library based on modern Web standards
- Created and maintained by Mike Bostock
- Website: https://d3js.org
- Documentation: https://github.com/d3/d3/wiki
- Gallery: https://observablehq.com/@d3/gallery

- D3 stands for Data-Driven Documents
- Concentrates on the data as opposed to the representation
- High expressiveness: good for custom/novel forms

WHAT D3 DOES

1. Loads data in the browser (DOES NOT HIDE THE DATA!)
2. Binds data to document elements
3. Transforms elements by interpreting each element's bound datum and setting its visual properties
4. Transitions elements between states in response to user input

PROGRAMMING PARADIGMS & VIS TOOLS

Paradigm	**Imperative**	**Declarative**
Properties	○ Specify How to do ○ Lower-level ○ Less accessible	○ Specify What to do ○ Higher-level ○ More accessible
Examples	Google Charts Matplotlib WebGL	D3 ggplot2 Altair

D3 FUNCTION CHAINING OPERATIONS

Design pattern that makes code simpler to understand

Without chaining

```
obj.method3(obj.method2(obj.method1()));

//or
var s = obj.method1();
s = s.method2();
s = s.method3();
```

With chaining

```
obj.method1()
   .method2()
   .method3();
```

BASIC D3 OPERATIONS

1. Select elements

   A D3 selection is a list (or array) of nodes with a parent

```
var selection = d3.select(selector);  //select first matching element in the document
var selection = d3.selectAll(selector);  //select all matching elements in the document

//use chaining to select on the selection object
var selection = selection.select(selector);  //select first matching element in the selection
var selection = selection.selectAll(selector);  //select all matching elements in the selection

//EXAMPLES
var s = d3.select('body');  //selects <body> in <html>
s.select('p');  //selects first <p> in <body>

d3.select('body')  //same as above using chaining
  .select('p');

d3.selectAll('p');  //selects all <p> in parent
```

2. Add new elements to selected elements
3. Delete selected elements
4. Modify selected elements to position and style

BASIC D3 OPERATIONS

1. Select elements
2. Add new elements to selected elements

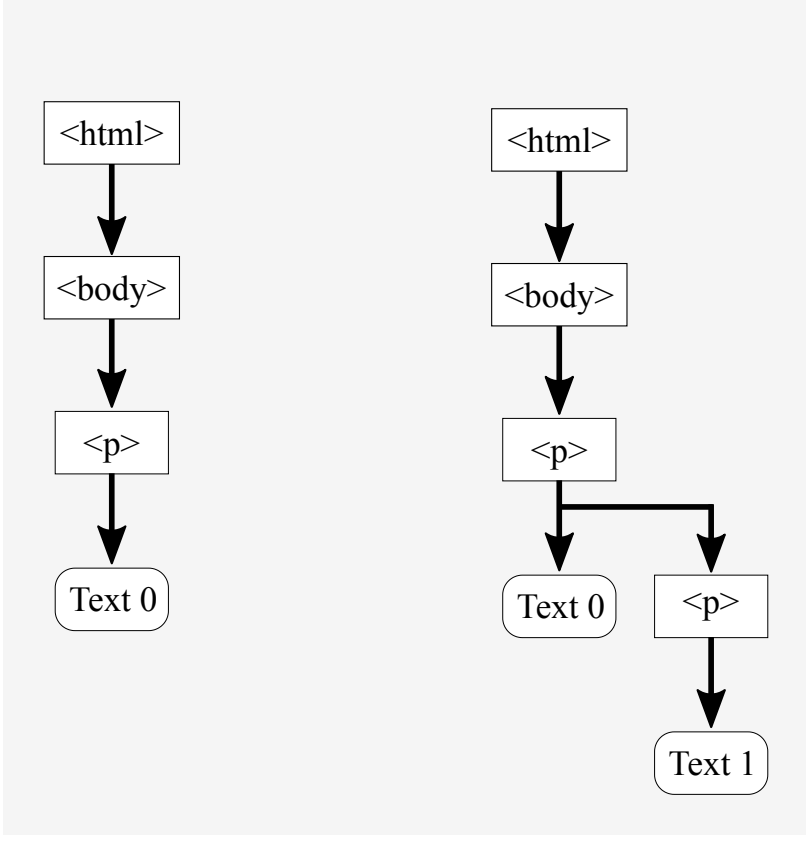
   `selection.append(type)` appends a new element to the last child of each selected element and return the added elements

```
//<body></body>
d3.select('body')
  .append('p')  //append p as the last child of body
  .text('Text0');  //set text to "Text0"
//<body><p>Text0</p></body>
d3.selectAll('p')  //selects all elements of type p
  .append('p')  //append p as the last child of the selection
  .text('Text1');  //set text to "Text1"
//<body><p>Text0<p>Text1</p></p></body>
```

3. Delete selected elements
4. Modify selected elements to position and style

DOM TREE OF EXAMPLE

```
//<body><p>Text0</p></body>
//<body><p>Text0<p>Text1</p></p></body>
```



BASIC D3 OPERATIONS

1. Select elements
2. Add new elements to selected elements
3. Delete selected elements

   Deleting is done with `selection.remove()` and returns the removed elements

```
//<body><p>Text0</p></body>
d3.selectAll('p')  //selects all elements of type p
  .remove();  //removes selected elements
//<body></body>
```

4. Modify selected elements to position and style

BASIC D3 OPERATIONS

1. Select elements
2. Add new elements to selected elements
3. Delete selected elements
4. Modify selected elements to position and style

   `selection.text()` and `selection.style()` `selection.attr()` changes the text, style and attributes of the element

```
//<p>Paragraph1</p>
//<p>Paragraph2</p>
d3.select('p')  //select first p in document
  .text('Paragraph0');
  .style('color', 'red');
//<p>Paragraph0</p>
//<p>Paragraph2</p>
```

DATA JOIN

- Mechanism to bind data to elements in the document
- Central to D3 operations
- Works on the selection!

Data join creating 3 paragraphs and setting their text to the data

```
var dataset = [0, 1, 2];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d) { return d; });
```

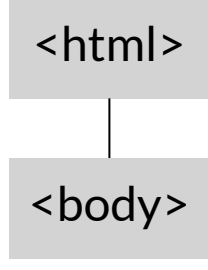
0

1

2

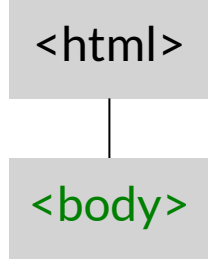
DATA JOIN EXAMPLE (1)

```
var dataset = [0, 1, 2];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d) { return d; });
```



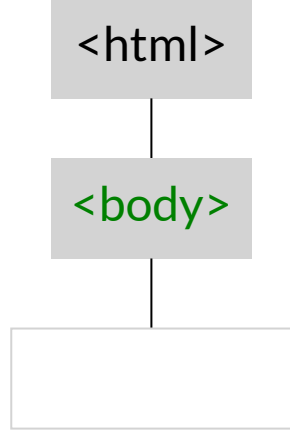
DATA JOIN EXAMPLE (2)

```
var dataset = [0, 1, 2];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d) { return d; });
```



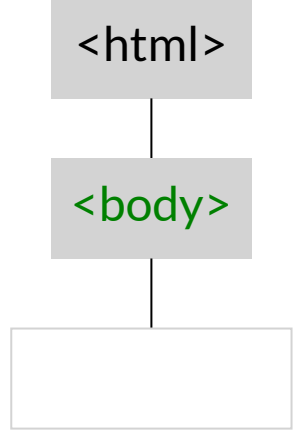
DATA JOIN EXAMPLE (3)

```
var dataset = [0, 1, 2];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d) { return d; });
```



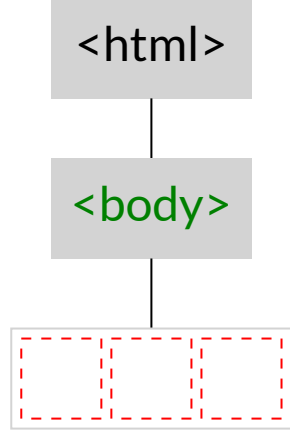
DATA JOIN EXAMPLE (4)

```
var dataset = [0, 1, 2];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d) { return d; });
```



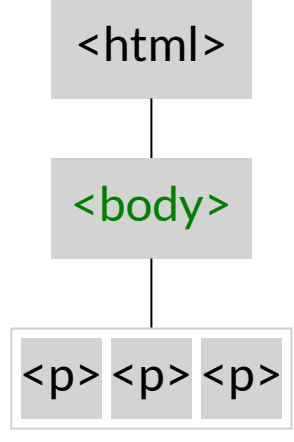
DATA JOIN EXAMPLE (5)

```
var dataset = [0, 1, 2];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d) { return d; });
```



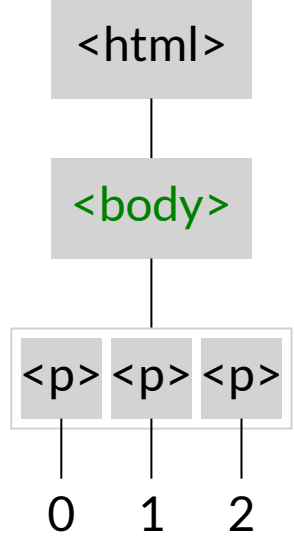
DATA JOIN EXAMPLE (6)

```
var dataset = [0, 1, 2];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d) { return d; })
```



DATA JOIN EXAMPLE (7)

```
var dataset = [0, 1, 2];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d) { return d; });
```



CONFIGURATION FUNCTIONS PARAMETERS

Configurations functions take datum and optional index as arguments

```
var dataset = [1, 2, 3];

d3.select('body')
  .selectAll('p')
  .data(dataset)
  .enter()
  .append('p')
  .text(function(d, i) { return 'd=' + d + ' i=' + i; })
  .style('color', function(d, i) { return (i % 2) ? 'red' : 'blue'; });
```

d=1 i=0

d=2 i=1

d=3 i=2

DATASET MUST BE AN ARRAY!

```
var dataset = [1, 2, 3];

d3.select('body')
  .selectAll('p')
  .data(dataset) //must be an array!
  .enter()
  ...
```

```
var data = [  //array of objects
  {name: 'A', frequency: .08167},
  {name: 'B', frequency: .01492},
  {name: 'C', frequency: .02780},
  {name: 'D', frequency: .04253},
  {name: 'E', frequency: .12702}
];

var data = [  //array of arrays
  [ 0,  1,  2,  3],
  [ 4,  5,  6,  7],
  [ 8,  9, 10, 11],
  [12, 13, 14, 15]
];
```

Examples of valid arrays that can be passed to data()

OUTLINE

- Design space and design trade-offs
- Graphing in the browser
- Introduction to D3
- Quiz questions

What will appear on the page?

```
<svg>
<polygon points="60,10 100,30 100,70 60,90 20,70 20,30" fill="tan">SVG</polygon>
</svg>
```

A. Nothing
B. Tan polygon
C. Tan polygon with SVG text
D. SVG text

What will appear on the page?

```
<svg>
<polygon points="60,10 100,30 100,70 60,90 20,70 20,30" fill="tan">SVG</polygon>
</svg>
```

A. Nothing
B. Tan polygon
C. Tan polygon with SVG text
D. SVG text

Solution: B

What will appear on the page?

```
<svg>
  <circle cx="100" cy="100" fill="red"/>
  <text>Hello</text>
</svg>
```

A. Red circle
B. Red circle and text
C. Text
D. Nothing

What will appear on the page?

```
<svg>
  <circle cx="100" cy="100" fill="red"/>
  <text>Hello</text>
</svg>
```

A. Red circle
B. Red circle and text
C. Text
D. Nothing

Solution: D

What choice corresponds to the figure shown?

```
<svg style="background-color: lightgrey">
  <rect A="100" B="0" C="50" D="200" fill="red"/>
</svg>
```

A. A = x1, B = y1, C = x2, D = y2

B. A = y1, B = x1, C = y2, D = x2

C. A = x, B = y, C = width, D = height

D. A = y, B = x, C = height, D = width

What choice corresponds to the figure shown?

```
<svg style="background-color: lightgrey">
  <rect A="100" B="0" C="50" D="200" fill="red"/>
</svg>
```

A. A = x1, B = y1, C = x2, D = y2

B. A = y1, B = x1, C = y2, D = x2

C. A = x, B = y, C = width, D = height

D. A = y, B = x, C = height, D = width

Solution: D

What will appear on the page?

```
<body>
  <p>Paragraph1</p>
  <p>Paragraph2</p>

  <script type="text/javascript">
  d3.selectAll('p')
    .text('Paragraph1');
  d3.select('p')
    .text('Paragraph2')
    .style('color', 'red');
  </script>
</body>
```

A. Paragraph1
   Paragraph2
B. Paragraph2
   Paragraph1
C. Paragraph1
   Paragraph2
D. Paragraph2
   Paragraph1

What will appear on the page?

```
<body>
  <p>Paragraph1</p>
  <p>Paragraph2</p>

  <script type="text/javascript">
  d3.selectAll('p')
    .text('Paragraph1');
  d3.select('p')
    .text('Paragraph2')
    .style('color', 'red');
  </script>
</body>
```

A. Paragraph1
   Paragraph2
B. Paragraph2
   Paragraph1
C. Paragraph1
   Paragraph2
D. Paragraph2
   Paragraph1

Solution: B

What will appear on the page?

```
<body>
  <script type="text/javascript">
    d3.select("div").text("div").style("color", "orange");
  </script>
</body>
```

A. Error because text does not have the color property
B. Blank page
C. Error because div does not support text
D. div

What will appear on the page?

```
<body>
  <script type="text/javascript">
    d3.select("div").text("div").style("color", "orange");
  </script>
</body>
```

A. Error because text does not have the color property
B. Blank page
C. Error because div does not support text
D. div

Solution: B

What will appear on the page?

```
<body>
  <p>text</p>
  <script type="text/javascript">
    d3.selectAll("p").text("p").style("color", "orange");
  </script>
</body>
```

A. Error because text does not have a style property
B. Blank page
C. Error because p does not support text
D. p

What will appear on the page?

```
<body>
  <p>text</p>
  <script type="text/javascript">
    d3.selectAll("p").text("p").style("color", "orange");
  </script>
</body>
```

A. Error because text does not have a style property
B. Blank page
C. Error because p does not support text
D. p

Solution: D

What will appear on the page?

```
<body>
  <span>Potato </span>
  <script type="text/javascript">
    d3.select("body").select("span").text("Tomato ");
    d3.selectAll("span").append("span").text("Salad ");
    d3.selectAll("span").append("span").text("Carrot ");
  </script>
</body>
```

A. Potato Tomato Salad Carrot
B. Tomato Salad Carrot
C. Tomato Salad Carrot Carrot
D. Potato

What will appear on the page?

```
<body>
  <span>Potato </span>
  <script type="text/javascript">
    d3.select("body").select("span").text("Tomato ");
    d3.selectAll("span").append("span").text("Salad ");
    d3.selectAll("span").append("span").text("Carrot ");
  </script>
</body>
```

A. Potato Tomato Salad Carrot
B. Tomato Salad Carrot
C. Tomato Salad Carrot Carrot
D. Potato

Solution: C

What will appear on the page?

```
var dataset = ["red ", "blue ", "red ", "blue ", "red "];

d3.select('body').selectAll('span')
  .data(dataset)
  .enter()
  .append('span')
  .text(function (d) { return d });

d3.selectAll("span")
  .style("text-decoration", function (d, i) { return (i % 2) ? "none" : "underline"; })
  .append("span").text("blue ");
```

A. red blue red blue red
B. red blue red blue red
C. red blue blue blue red blue blue blue red blue
D. red blue blue blue red blue blue blue red blue

What will appear on the page?

```
var dataset = ["red ", "blue ", "red ", "blue ", "red "];

d3.select('body').selectAll('span')
  .data(dataset)
  .enter()
  .append('span')
  .text(function (d) { return d });

d3.selectAll("span")
  .style("text-decoration", function (d, i) { return (i % 2) ? "none" : "underline"; })
  .append("span").text("blue ");
```

A. red blue red blue red

B. red blue red blue red

C. red blue blue blue red blue blue blue red blue

D. red blue blue blue red blue blue blue red blue

Solution: C

What will appear on the page?

```
<body>
<script type="text/javascript">
  var dataset = ['red ', 'blue ', 'red ', 'blue ', 'red '];

  d3.select('body')
    .selectAll('span')
    .data(dataset)
    .enter()
    .append('span')
    .text(function (d) { return d });

  d3.selectAll("span")
    .style("text-decoration", "underline");

  dataset = shuffle(dataset);
  d3.select('body')
    .selectAll('span')
    .data(dataset)
    .enter()
    .append('span')
    .text(function (d) { return d });

  d3.selectAll("span")
    .style("text-decoration", "none");

  function shuffle(array) {  // Shuffles array.
    var m = array.length, t, i;
    while (m) {
      i = Math.floor(Math.random() * m--);
      t = array[m], array[m] = array[i], array[i] = t;
    }
    return array;
  }
</script>
</body>
```

A. red blue red blue red
B. red blue red blue red
C. red blue red blue red red blue red blue red
D. red blue red blue red red blue red blue red

What will appear on the page?

```
<body>
<script type="text/javascript">
  var dataset = ['red ', 'blue ', 'red ', 'blue ', 'red '];

  d3.select('body')
    .selectAll('span')
    .data(dataset)
    .enter()
    .append('span')
    .text(function (d) { return d });

  d3.selectAll("span")
    .style("text-decoration", "underline");

  dataset = shuffle(dataset);
  d3.select('body')
    .selectAll('span')
    .data(dataset)
    .enter()
    .append('span')
    .text(function (d) { return d });

  d3.selectAll("span")
    .style("text-decoration", "none");

  function shuffle(array) {  // Shuffles array.
    var m = array.length, t, i;
    while (m) {
      i = Math.floor(Math.random() * m--);
      t = array[m], array[m] = array[i], array[i] = t;
    }
    return array;
  }
</script>
</body>
```

A. red blue red blue red
B. red blue red blue red
C. red blue red blue red red blue red blue red
D. red blue red blue red red blue red blue red

Solution: B