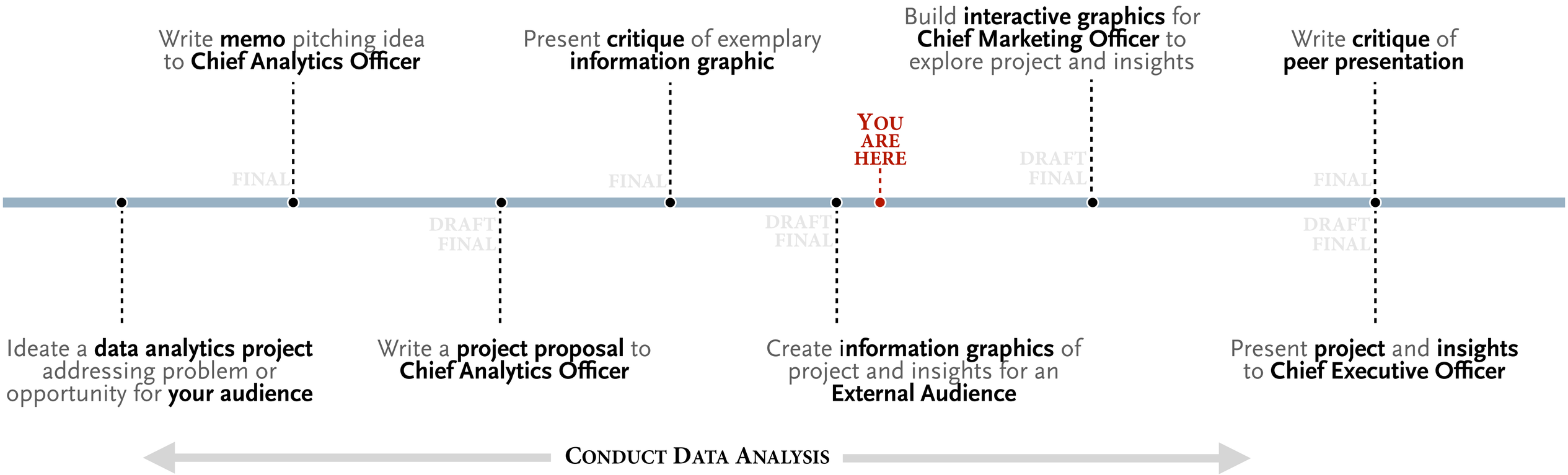
Storytelling with data

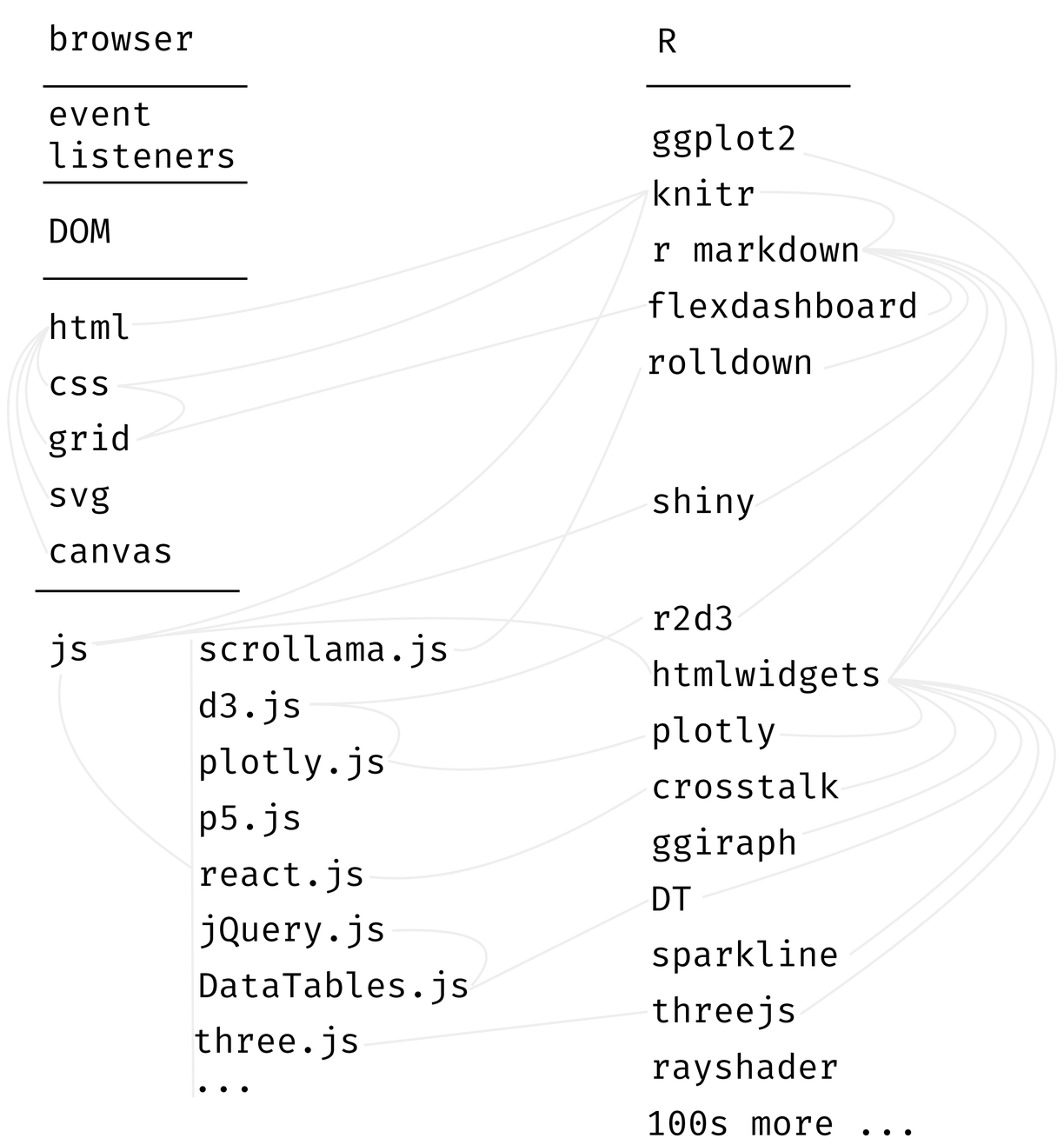
10 | Technologies and tools of interactive data-driven, visual design

course overview | main course deliverables

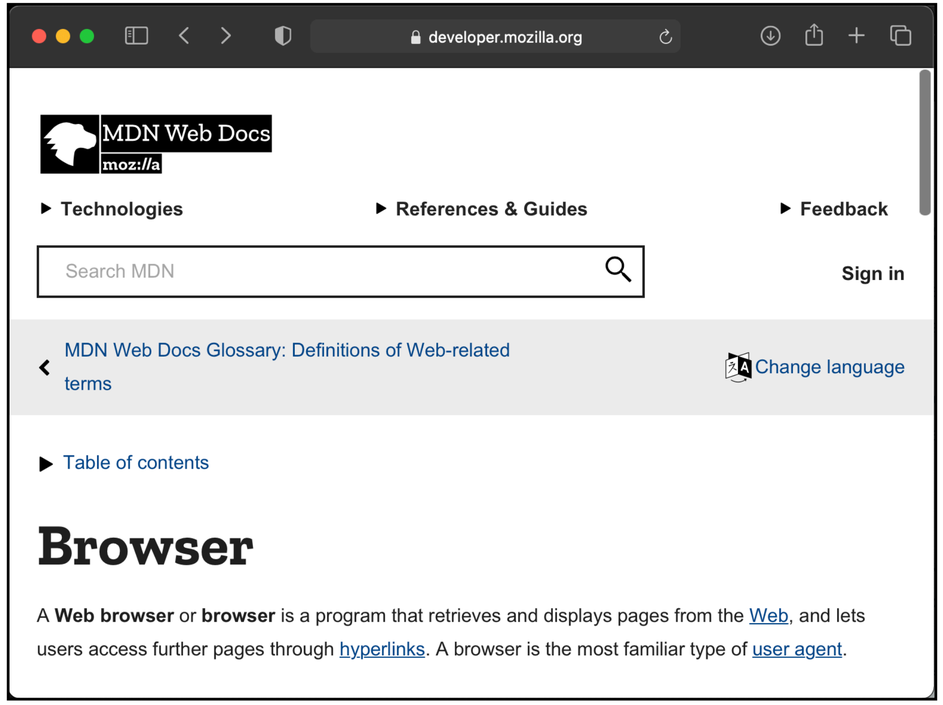


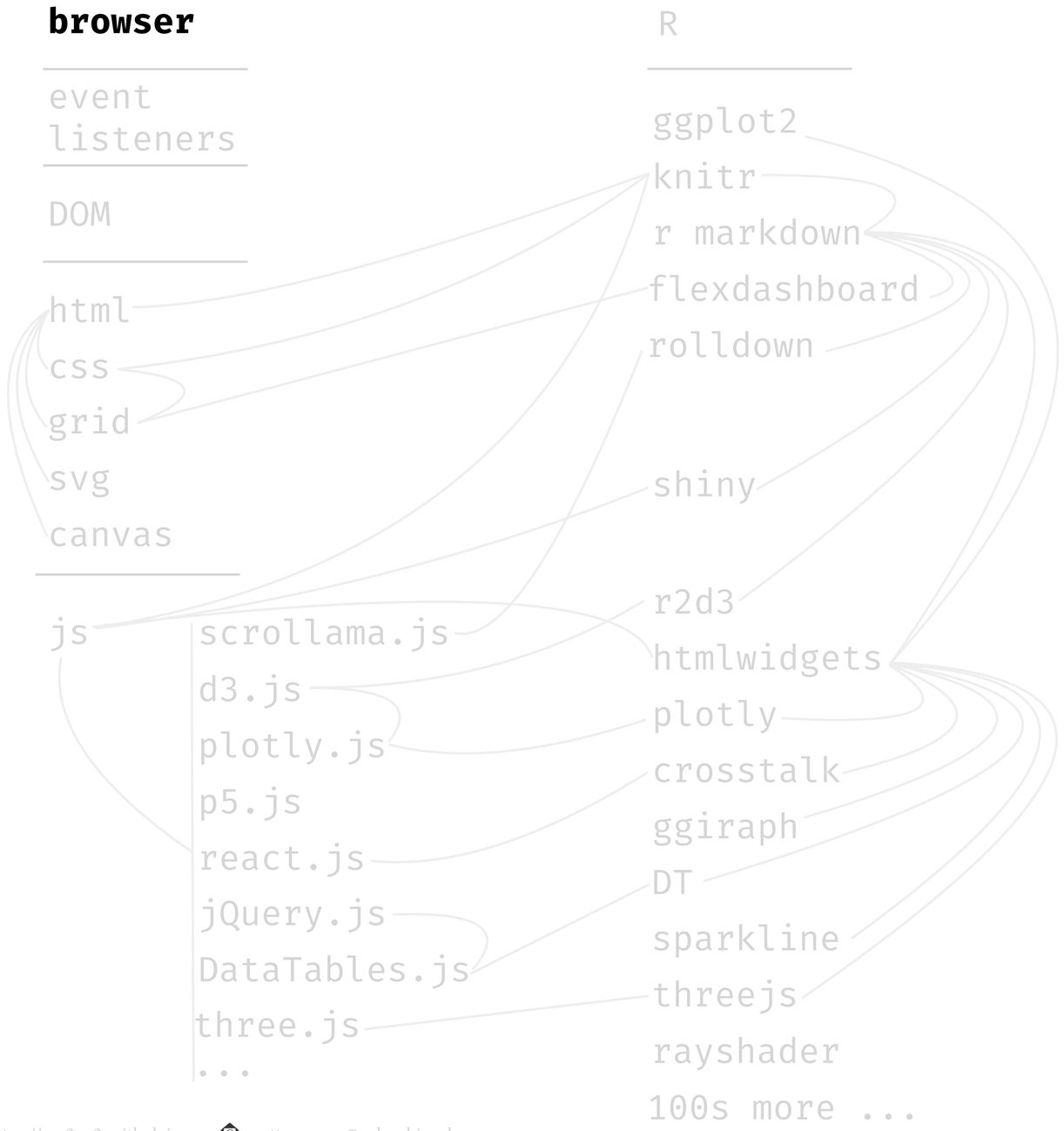
open-source technology stack for interactive, data-driven graphics

interactive technology stack, components and relationships — *click a technology below to learn more*

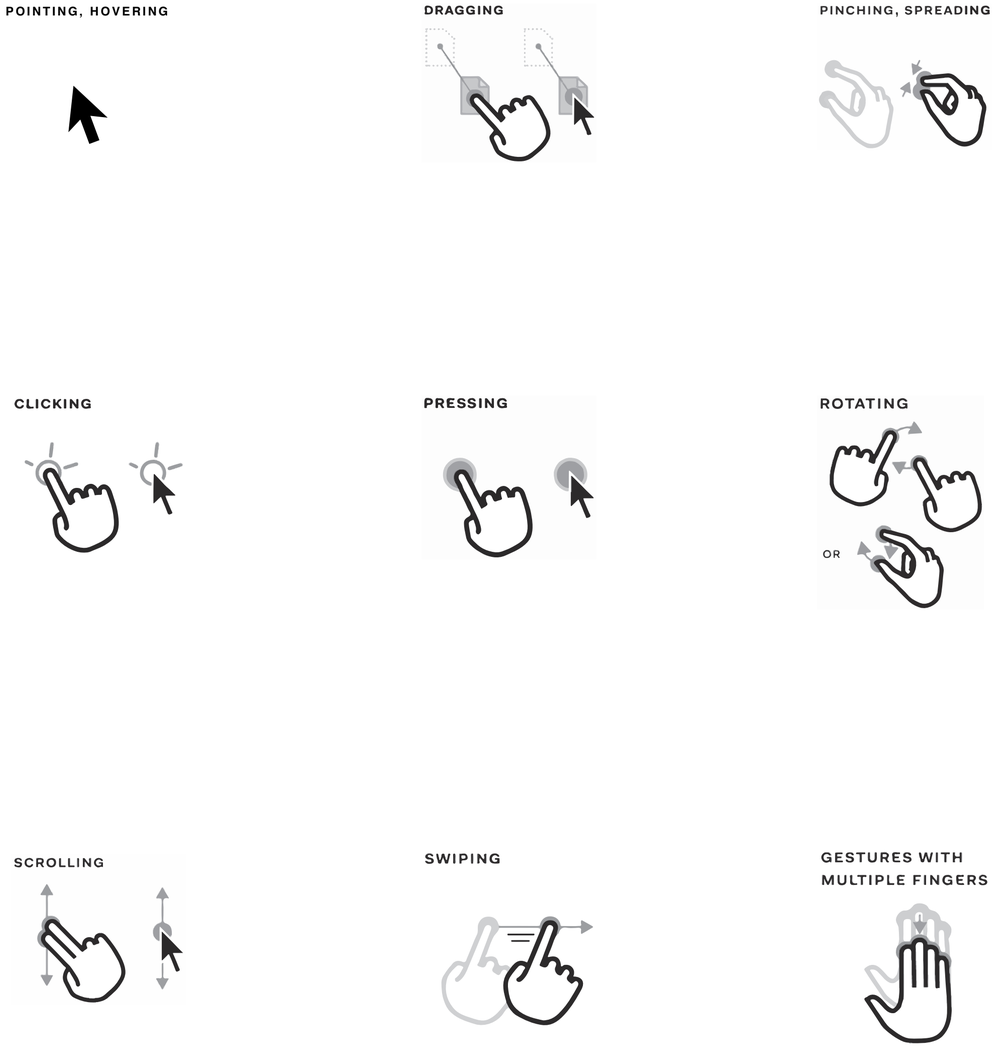


interactive technology stack, browsers parse various code to render content and respond to actions





interactive technology stack, actions trigger events, for which page elements can be bound to listen

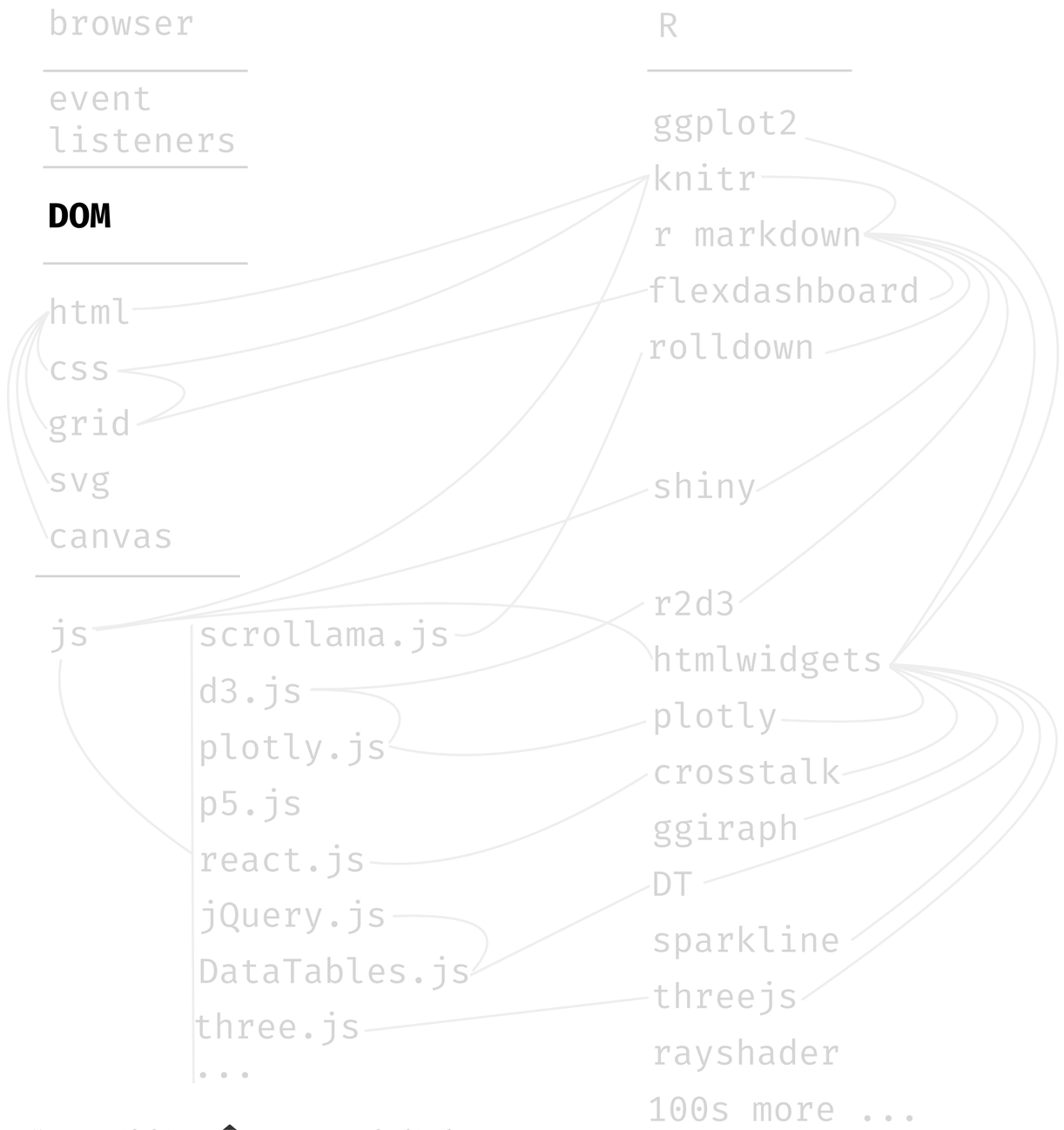


interactive technology stack, a web page includes several languages, each has a purpose

web page structure

(Interactive) web **pages** all begin and end with `<html>` and `</html>` respectively. contain a **head** and **body**. Content between `<body>` and `</body>` is shown inside the main browser window Before the `<body>` element you will often see a `<head>` element. This contains information *about* the page, rather than information that is shown within the main part of the browser window. You will usually find a `<title>` element and `<script>` (not shown below) element(s) inside the `<head>` element. Notice how tag enclosures create a *tree-like structure* we can traverse — that's the Document Object Model, or **DOM**.

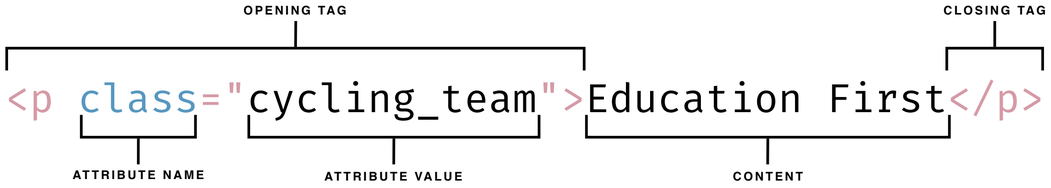
```
<html>
  <head>
    <title>This is the Title of the Page</title>
  </head>
  <body>
    <h1>This is in the Body of the Page</h1>
      <p>Anything within the body of a web page is
         displayed in the main browser window.</p>
  </body>
</html>
```

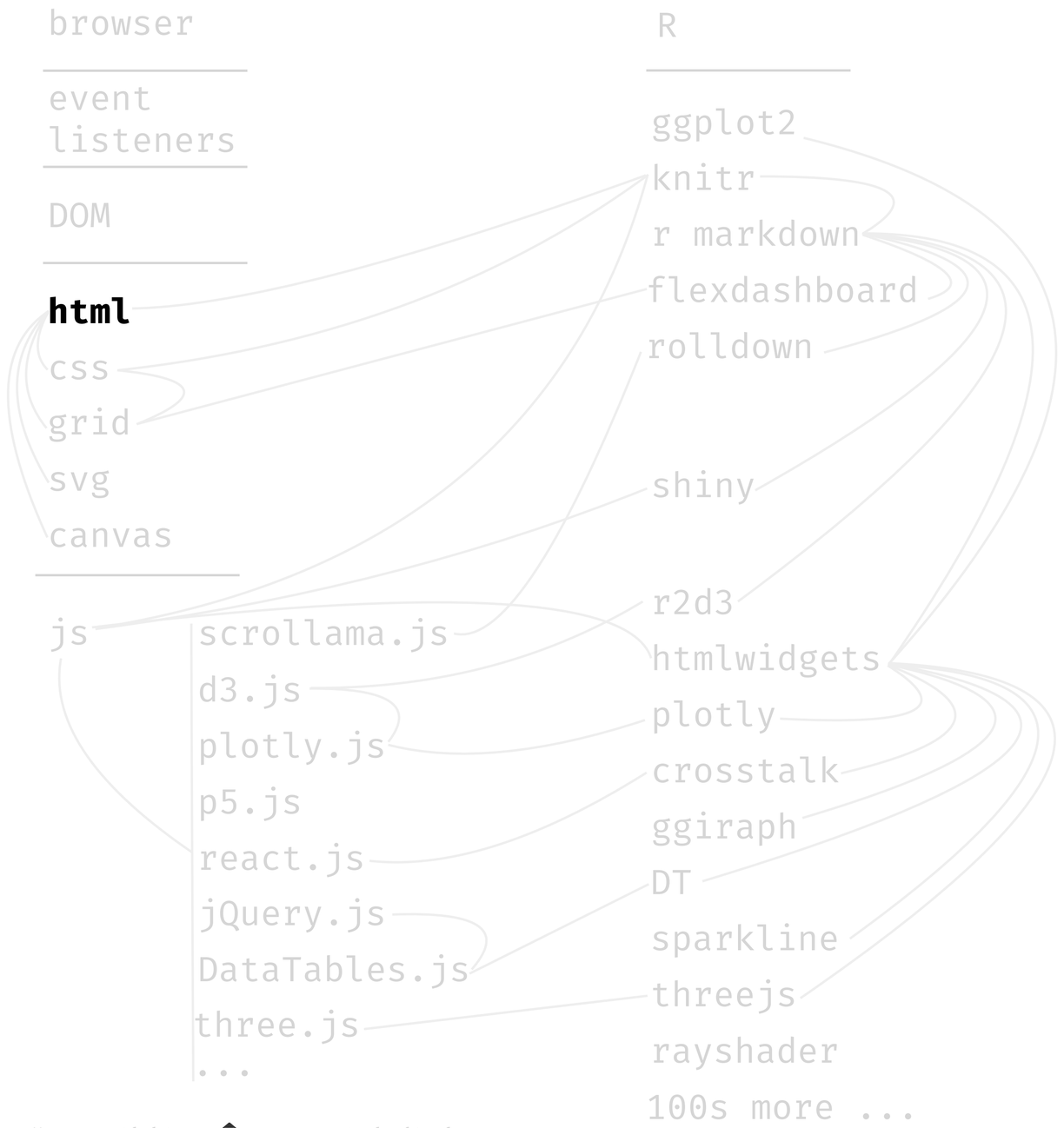


`html` elements

Added to the content of a **page** to describe its structure. An element consists of an *opening* and *closing* **tag** and its **content**. Opening tags can carry **attributes**.

The `<p></p>` below instructs the **browser** to structure the content as a paragraph. There are **many** pre-defined **tag types** and attributes, and we can define our own.

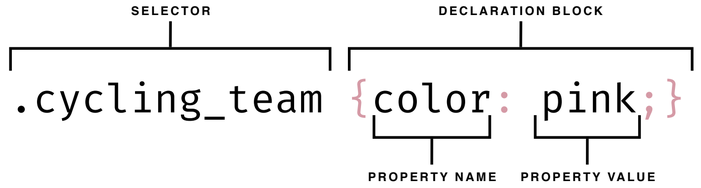




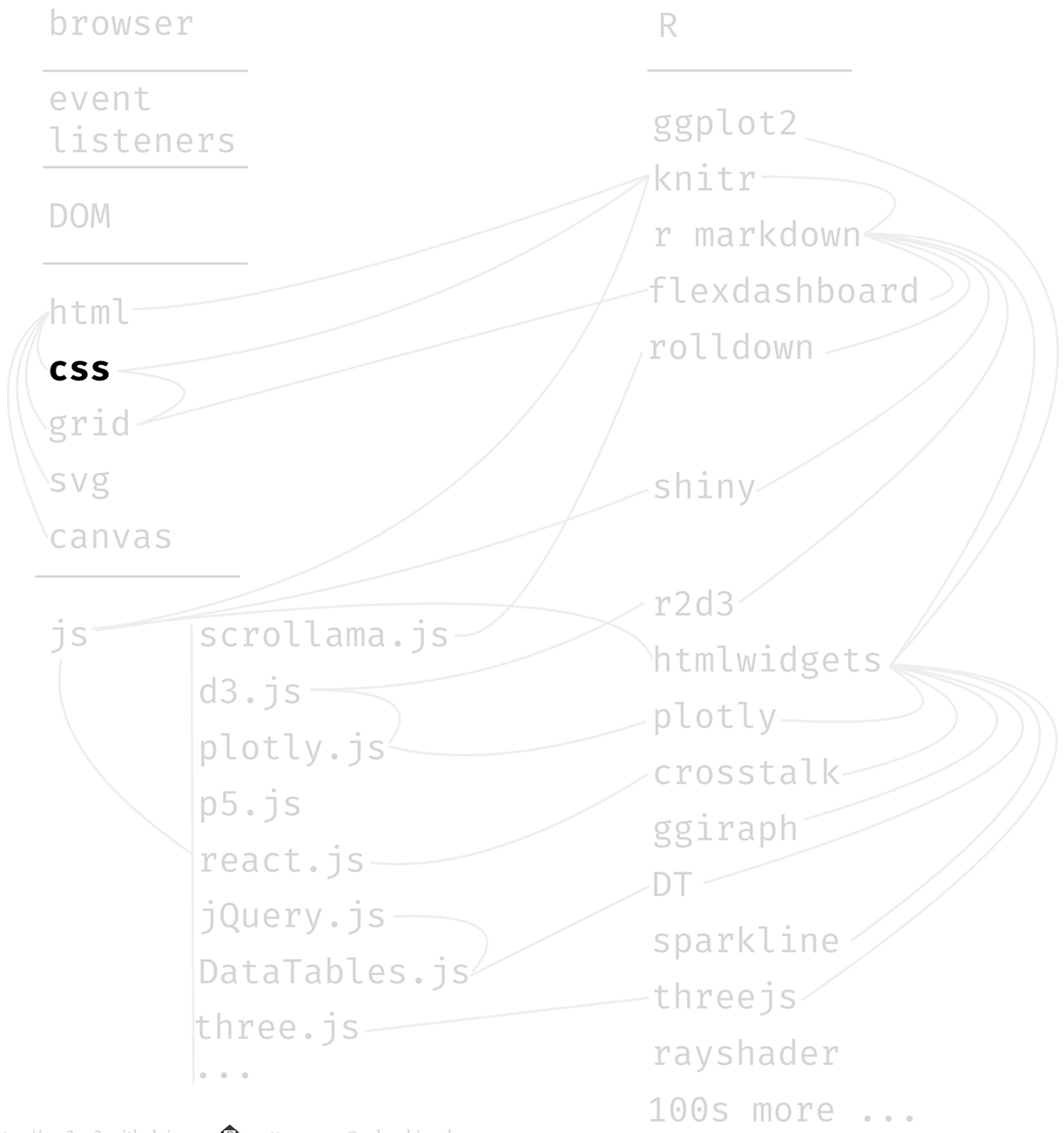
interactive technology stack, style the `html` elements using `css`, a presentation layer

`CSS` rules

Indicates how the contents of one or more elements should be displayed in the browser. Each rule has a selector and a declaration block. The **selector** indicates to which element(s) the rule applies. Each **declaration** block specifies one or more properties and corresponding values.Below, applying the **class** `.cycling_team` to a tag as an attribute, it will **color** the text a **pink** hue. CSS rules are specified within `<style>` elements.




```
<style>
  .cycling_team {
    color: pink;
  }
</style>
```

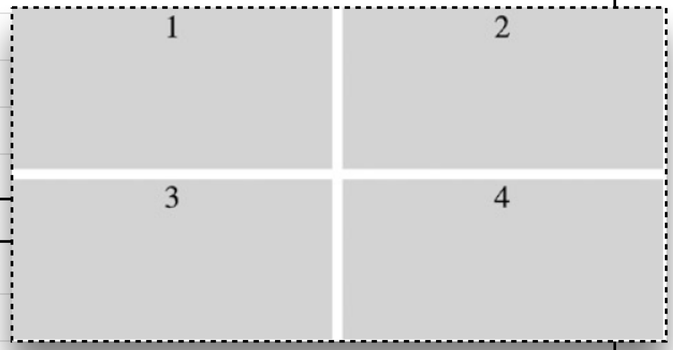


`CSS` grid

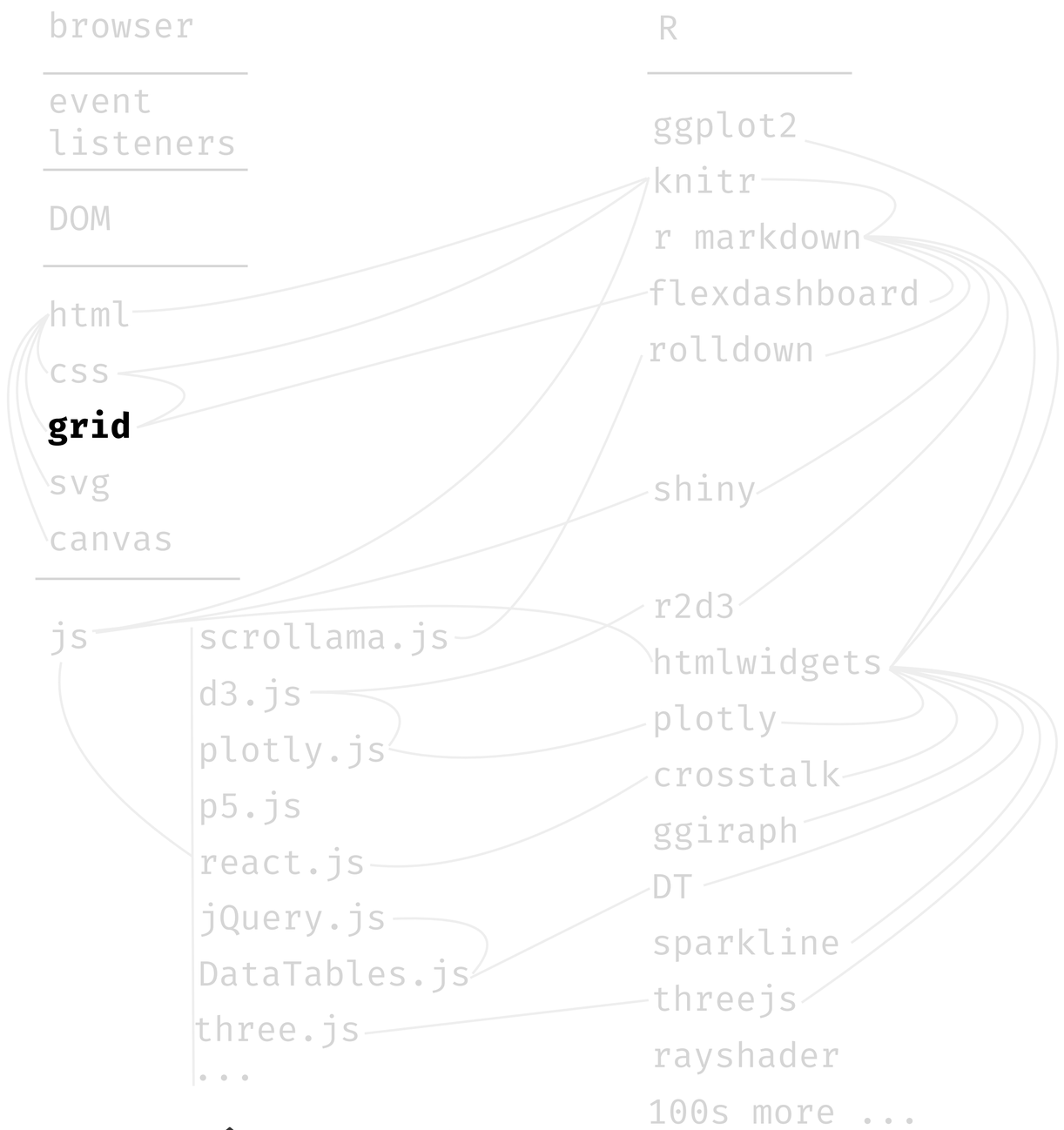
We've discussed and practiced using **grids** earlier in the semester to help us organize text and data graphics for memos, proposals, and information graphics. The `html` language includes grids we can specify using **tags**.

Below, we define a **class** `.container` and in that specify `{display: grid;}` and related properties. Then, we use the class attribute on **divider** tags `<div></div>`. The example below displays a 2 x 2 grid of **cells**, each with a size specified and placed in row major order.

```
<style>
  .container {
    display: grid;
    grid-template-columns: 10rem 10rem;
    grid-template-rows: 5rem 5rem;
    gap: 5px;
  }
  .item {
    background: lightgray;
    text-align: center;
  }
</style>
```




```
<div class="container">
  <div class="item">1</div>
  <div class="item">2</div>
  <div class="item">3</div>
  <div class="item">4</div>
</div>
```

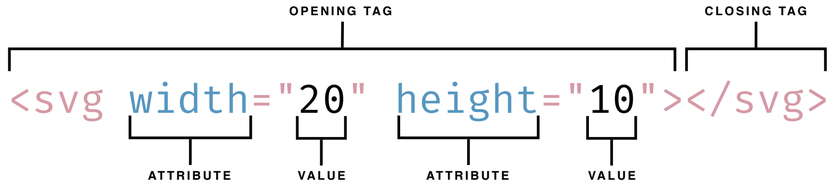


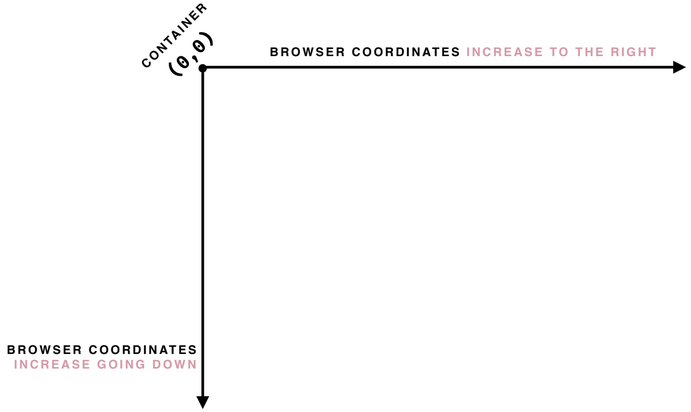
interactive technology stack, draw shapes within svg tags, a content layer

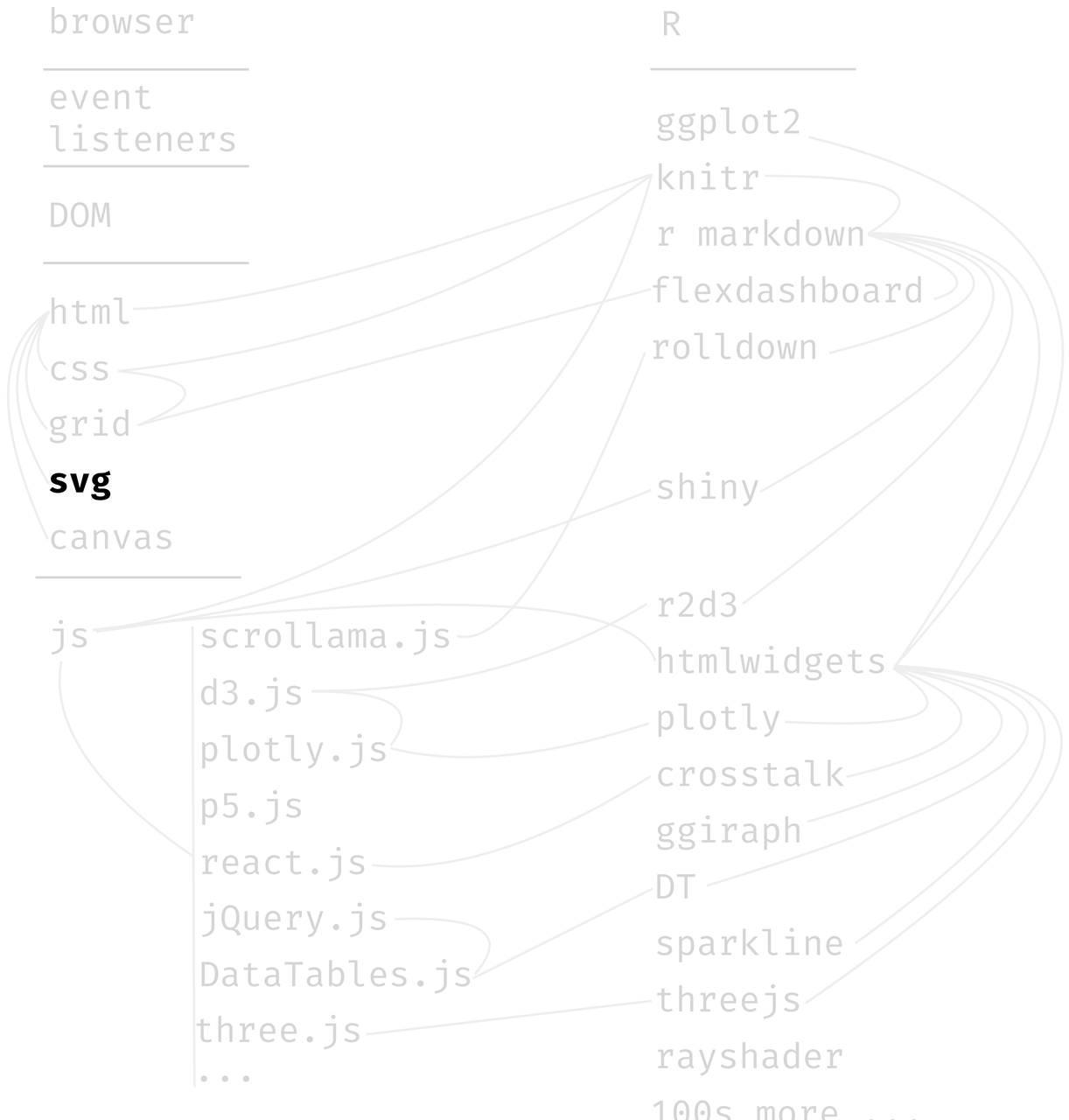
svg

Scalable vector graphics — **svg** — are human-readable descriptions of **shapes** or **paths** that the browser can display. As we've discussed, *enlarging* **vector** graphics, unlike raster-based graphics, will not reduce **resolution**. Together these paths and shapes comprise a graphic.

We put them in the `html` document body between **svg** `<svg>` and `</svg>` tags. Shapes I commonly use include the circle `<circle>`, rectangle `<rect>`, text `<text>`, path `<path>`, and group `<g>`. We can edit vector graphic shapes using software like Adobe Illustrator or Inkscape, too.







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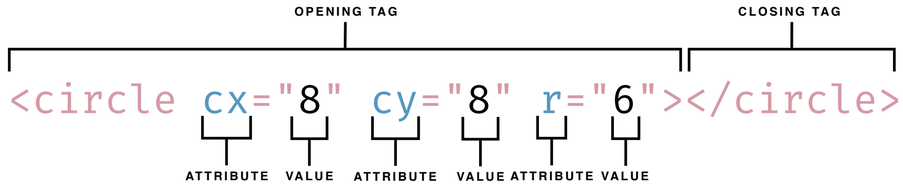
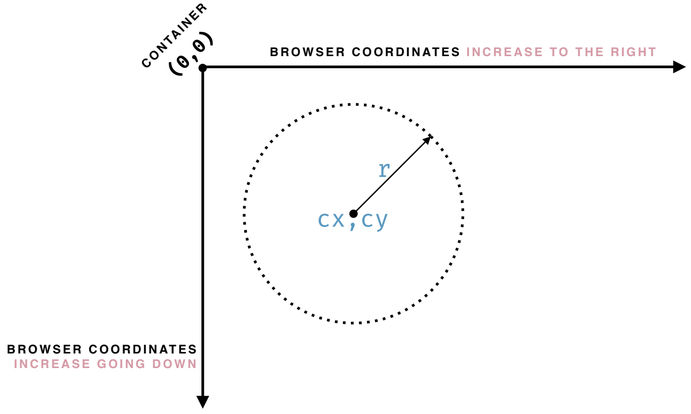
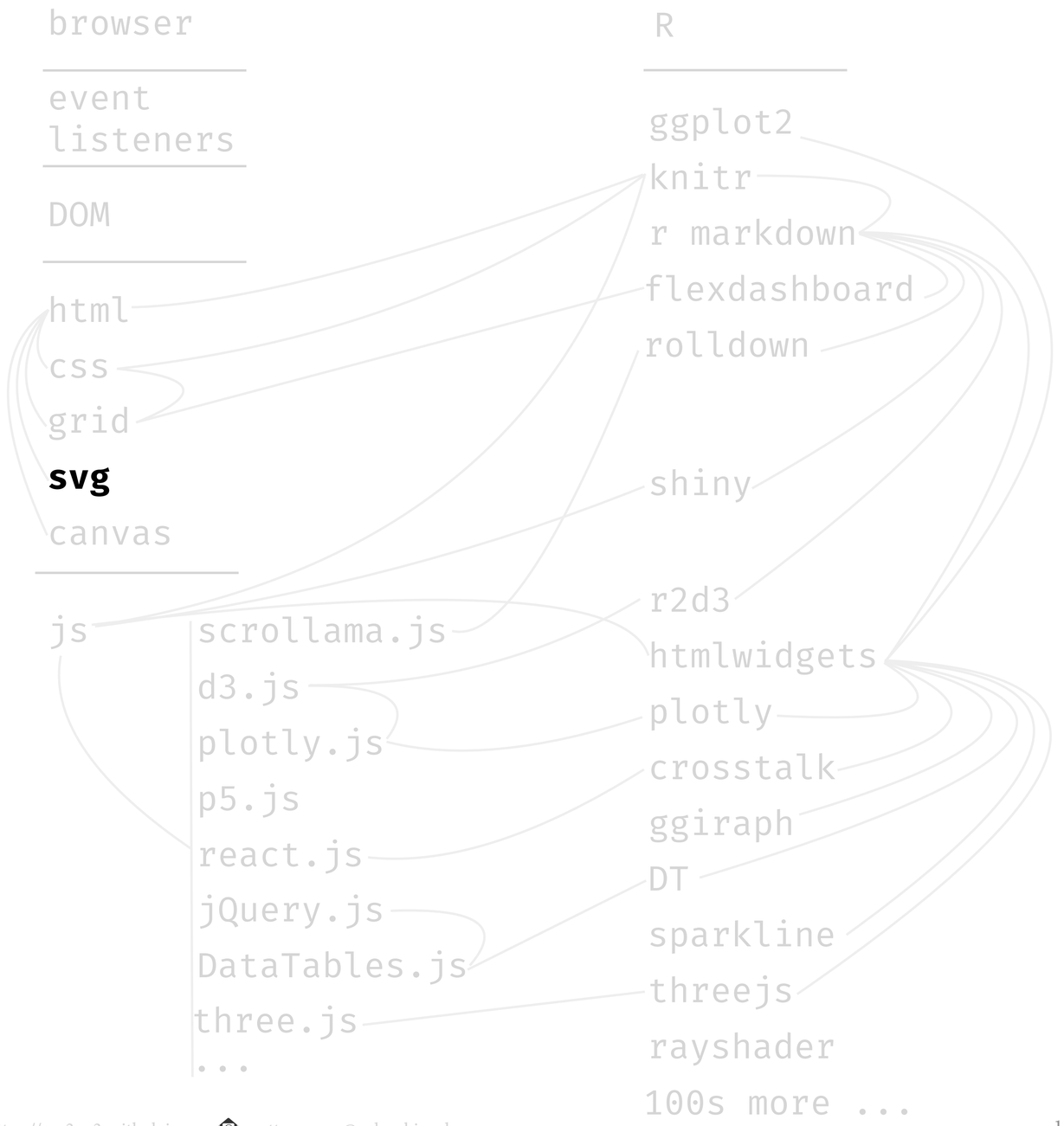




OTHER COMMON SHAPE ATTRIBUTES

```
stroke
stroke-width
stroke-opacity

fill
fill-color
fill-opacity
```



interactive technology stack, draw shapes within svg tags, a content layer

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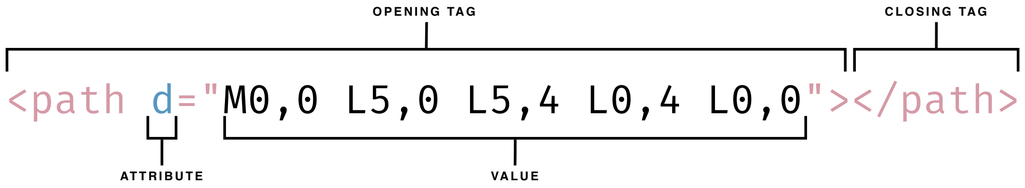
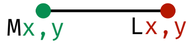
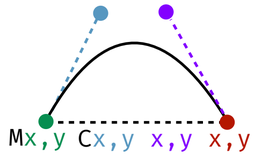
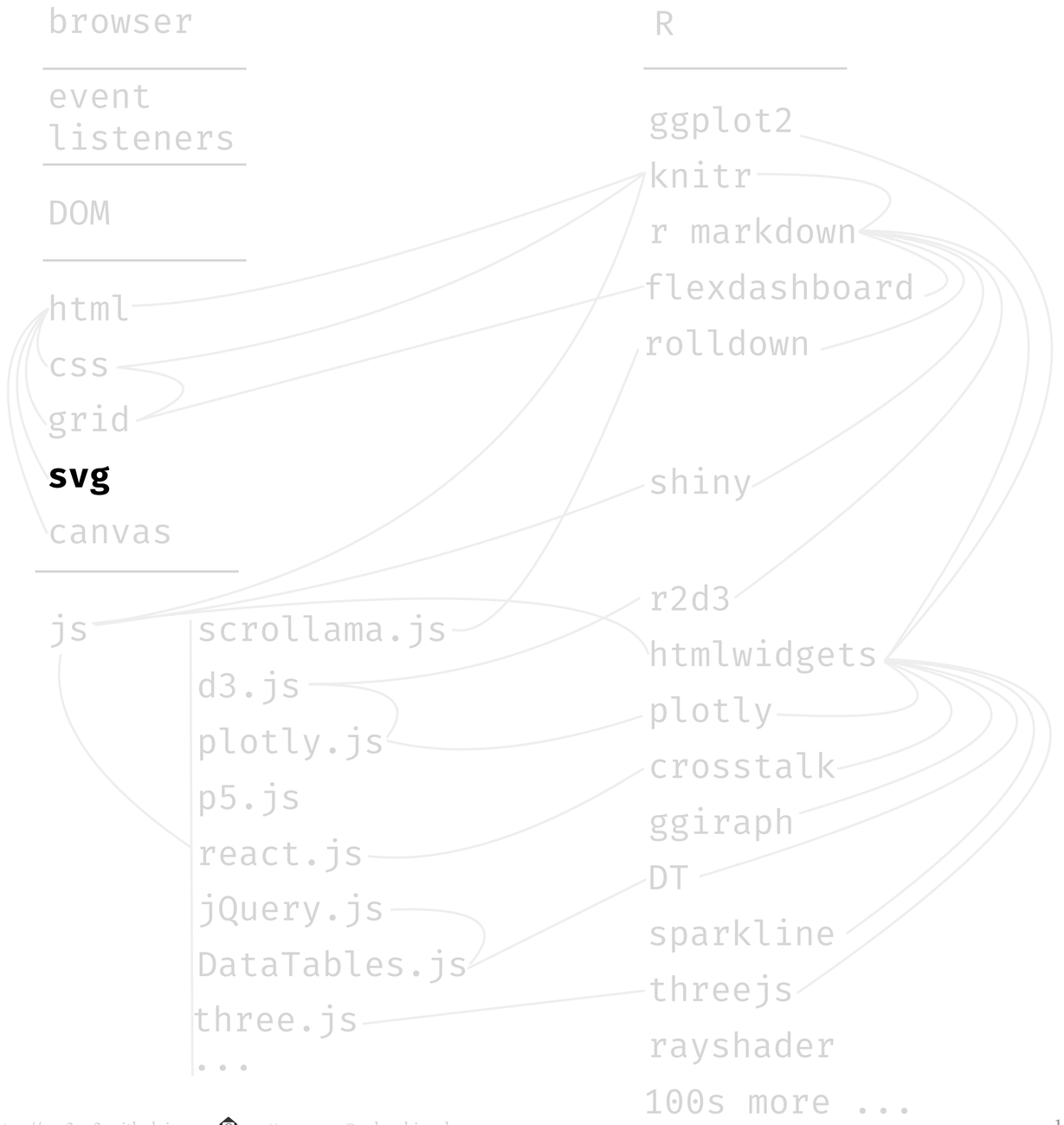




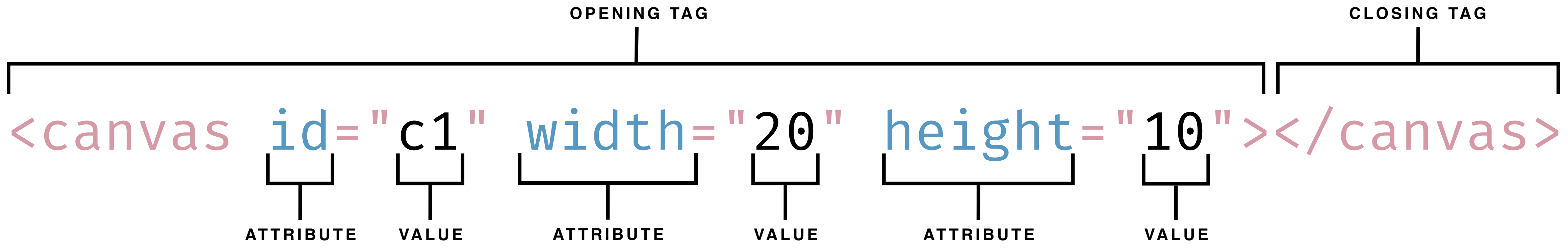


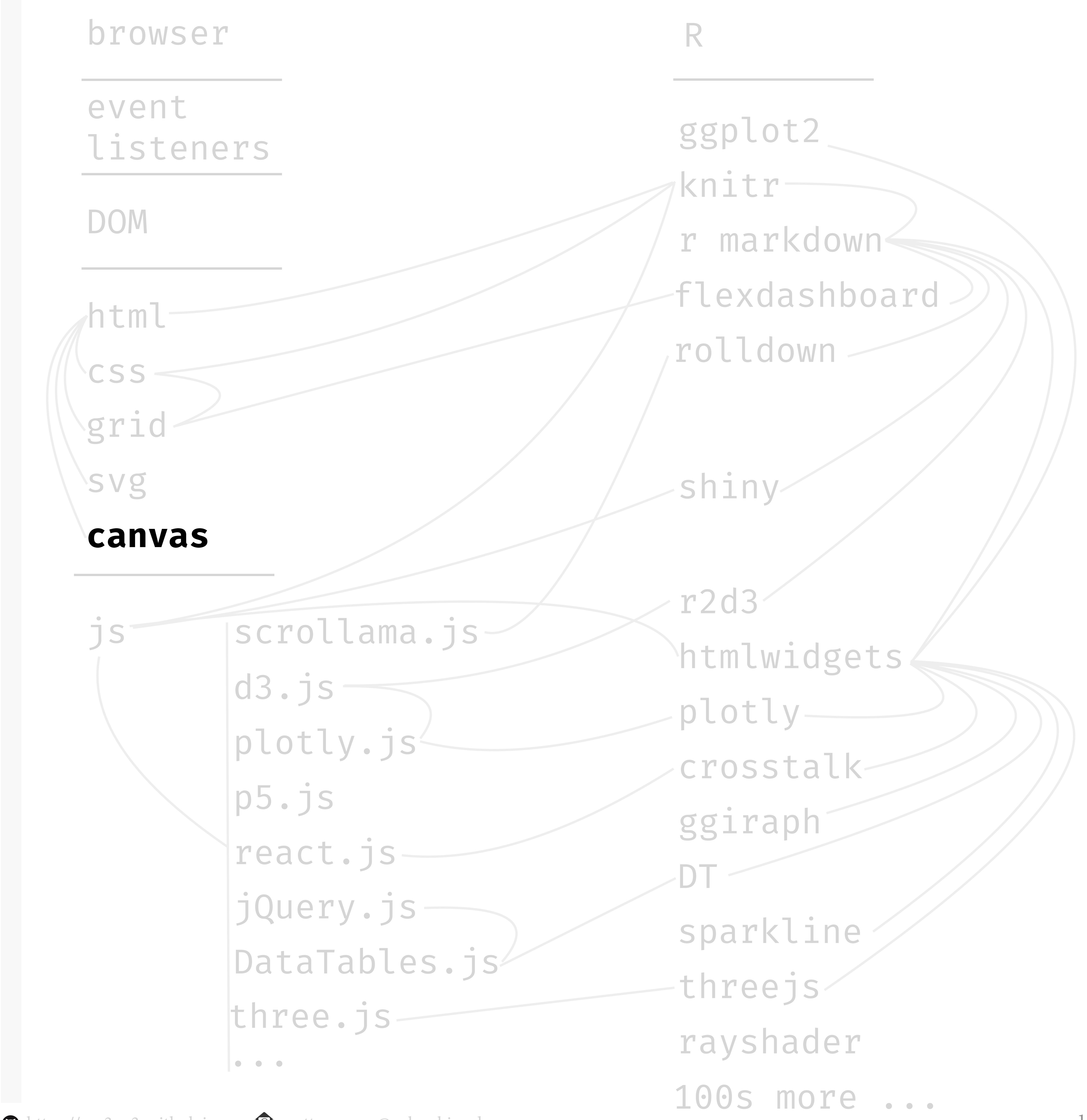
COMMAND	SYNTAX	MEANING
MOVE TO	Mx,y	location coordinate x, y where the drawing starts.
LINE TO	Lx,y	draw straight path from previous coordinate x, y to this coordinate x, y.
CURVE TO	Cx,y x,y x,y	draw curve path from previous coordinate x, y using two control points x, y and x,y to this coordinate x, y.



canvas

When **performance** drawing svg shapes becomes an issue—which may occur on slower computers with 1,000 to 10,000 shapes, more with today's computers—we gain performance by switching to **raster** graphics. For raster graphics, we draw **pixels** on **canvas**, which we specify within html using the <canvas></canvas> tag. From pixels, we cannot select shapes or paths like we can with svg graphics, and **resolution drops** upon **zooming** into the canvas. To edit rasters, we're better off using something like Photoshop.





interactive technology stack, **respond to events by changing content or style with `js`, a behavior layer**

JavaScript

We can ***bind*** **elements** to **events** that, upon happening, ***trigger javascript code***, which in turn can modify content: html elements and attributes, svg or canvas, or css styles. Really it **can modify anything in the DOM**. As with R packages that abstract and ease our application of specialized functionality, easing the burden of writing code, many **javascript libraries** are available to do the same. Those listed to the right are particularly important for interactive data visualization, but many more not listed are also available.

```
element.onevent = functionName;
```

- `element` — ELEMENT: DOM element node to target
- `onevent` — EVENT: Event bound to node(s) preceded by word "on".
- `functionName` — CODE: Name of function to call with no parenthesis following it.

```
function functionName() {
  // code to do something
}
```

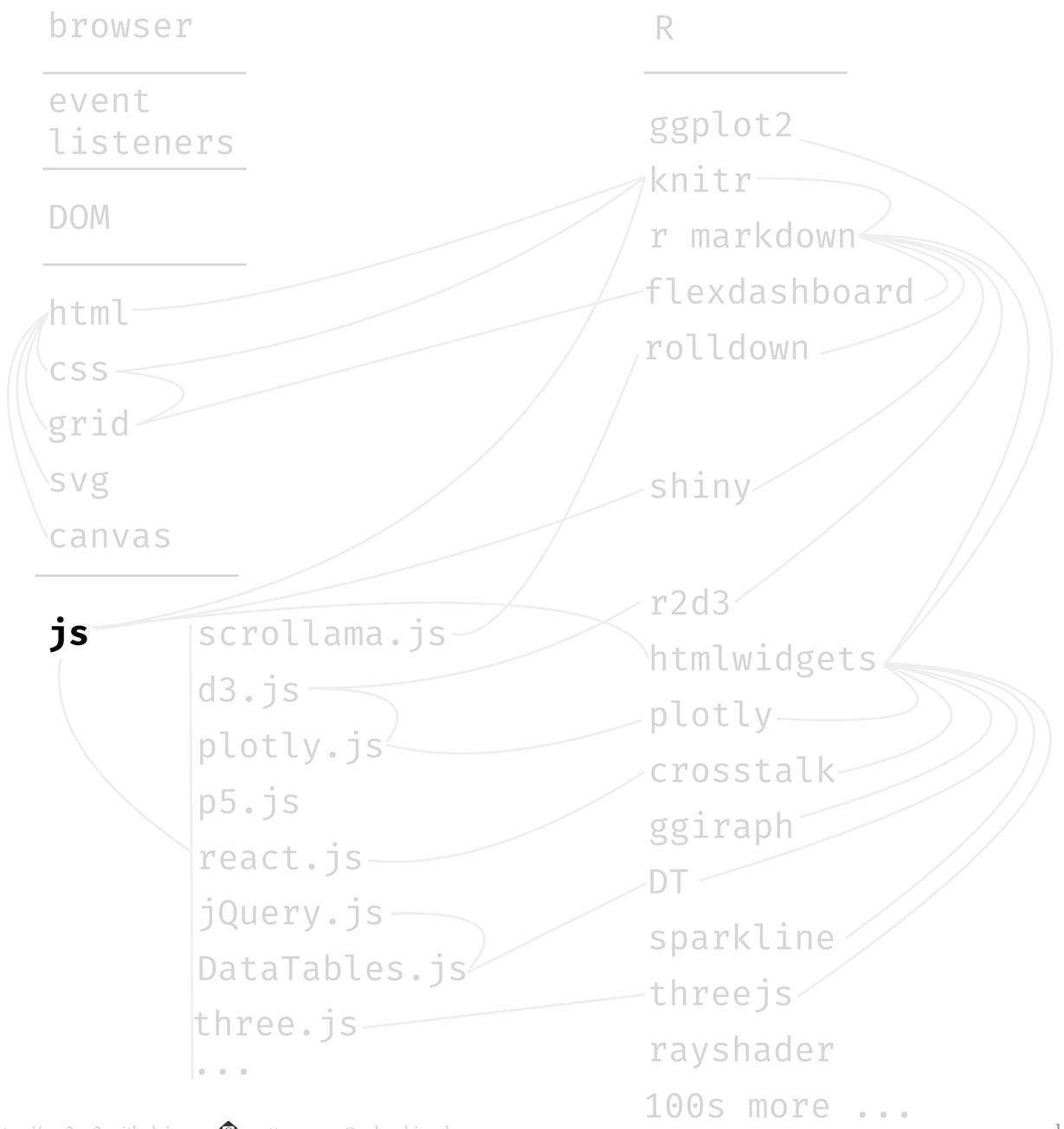
THE CODE STARTS BY DEFINING THE NAMED FUNCTION.

A REFERENCE TO THE DOM ELEMENT IS OFTEN STORED IN A VARIABLE.

```
var el = document.getElementById('element');
el.on_____ = functionName;
```

THE EVENT NAME IS PRECEDED BY THE WORD "ON".

THE FUNCTION IS CALLED BY THE EVENT HANDLER ON THE LAST LINE, BUT THE PARENTHESIS ARE OMITTED.



content creation for this interactive technology stack

Tool

Describe something here.

Describe more here.

tools for interactive content, several R packages transform ggplot2 into interactive graphics

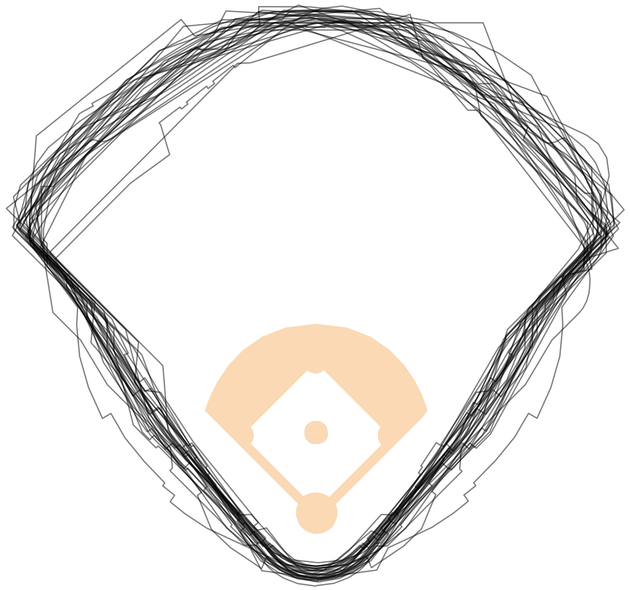
ggplot2

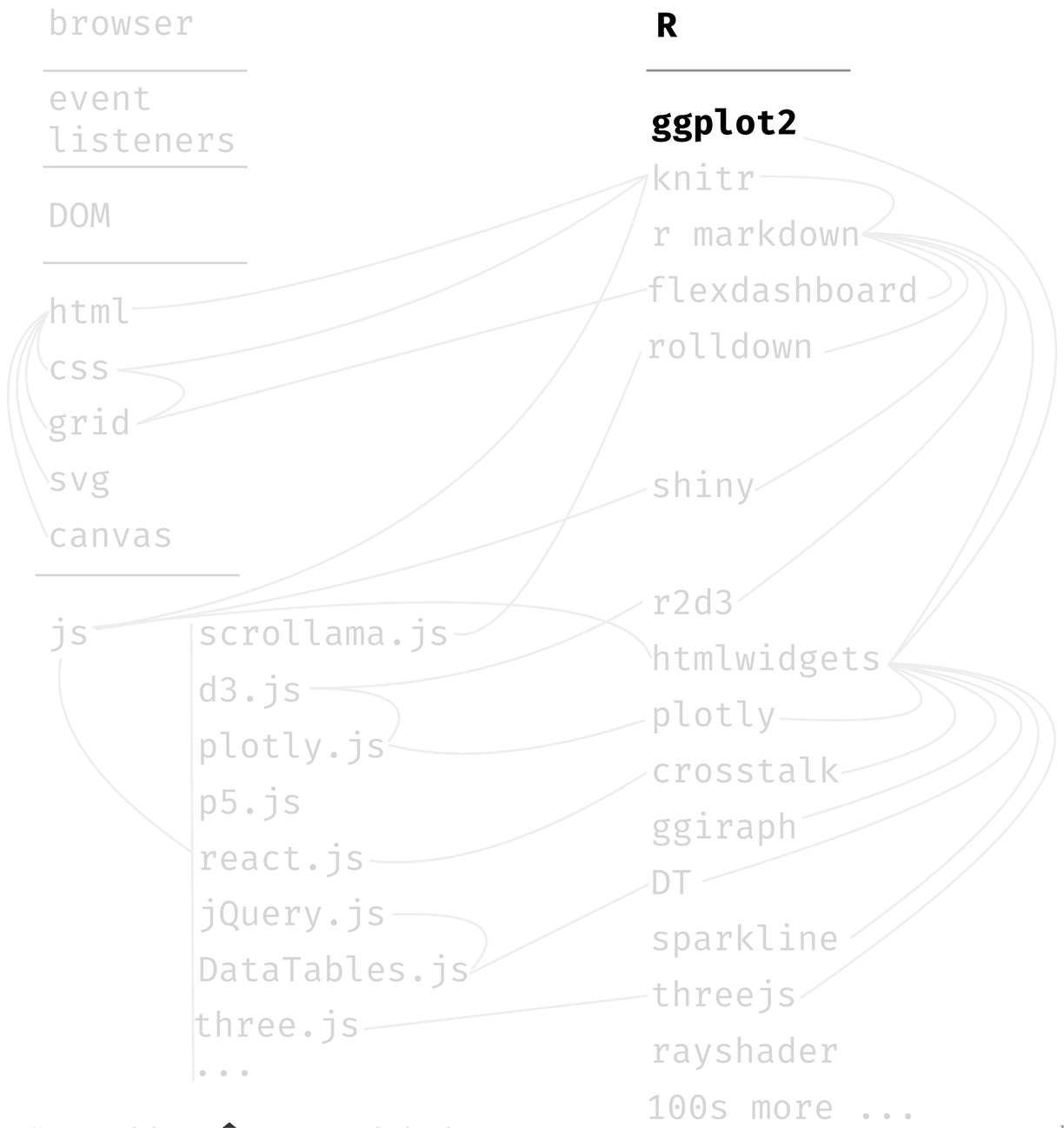
The **grammar of graphics** — implemented in R as ggplot2 — is among the most powerful coding libraries for creating static graphics. We've already seen how to use a complementary package with ggplot2 to add animation: gganimate, a grammar of animated graphics. With similar complementary packages, we can specify **interactivity**. Let's see a static version of a class example, the 30 baseball outfields, then make it interactive using ggiraph.

```
gg_boundaries <-
  ggplot() +
  theme_void() +
  coord_equal() +
  geom_path(
    data = filter(
      fields,
      is_infield == FALSE),
    mapping = aes(
      x = xsh,
      y = ysh,
      group = id),
    color = '#000000',
    alpha = 0.5) +

  geom_polygon(
    data = filter(
      fields,
      is_infield == TRUE),
    mapping = aes(
      x = xsh,
      y = ysh,
      group = id),
    fill = '#FAD9B4',
    color = '#FAD9B4')
```

30 baseball outfields — *static* version





tools for interactive content, several R packages transform ggplot2 into interactive graphics

ggplot2 + ggiraph

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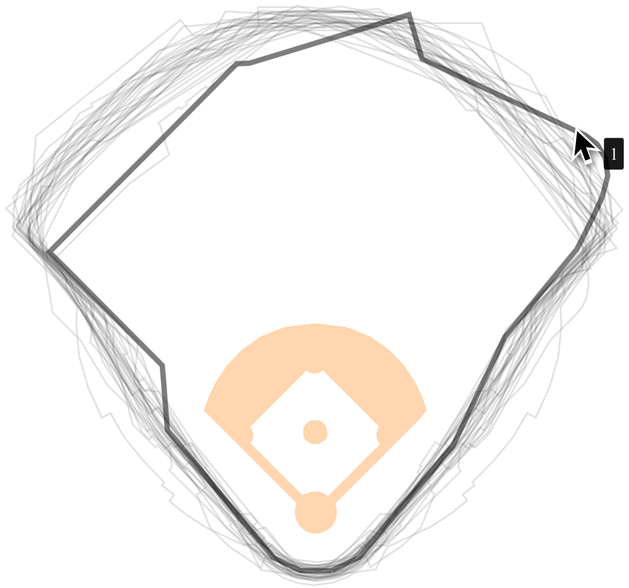
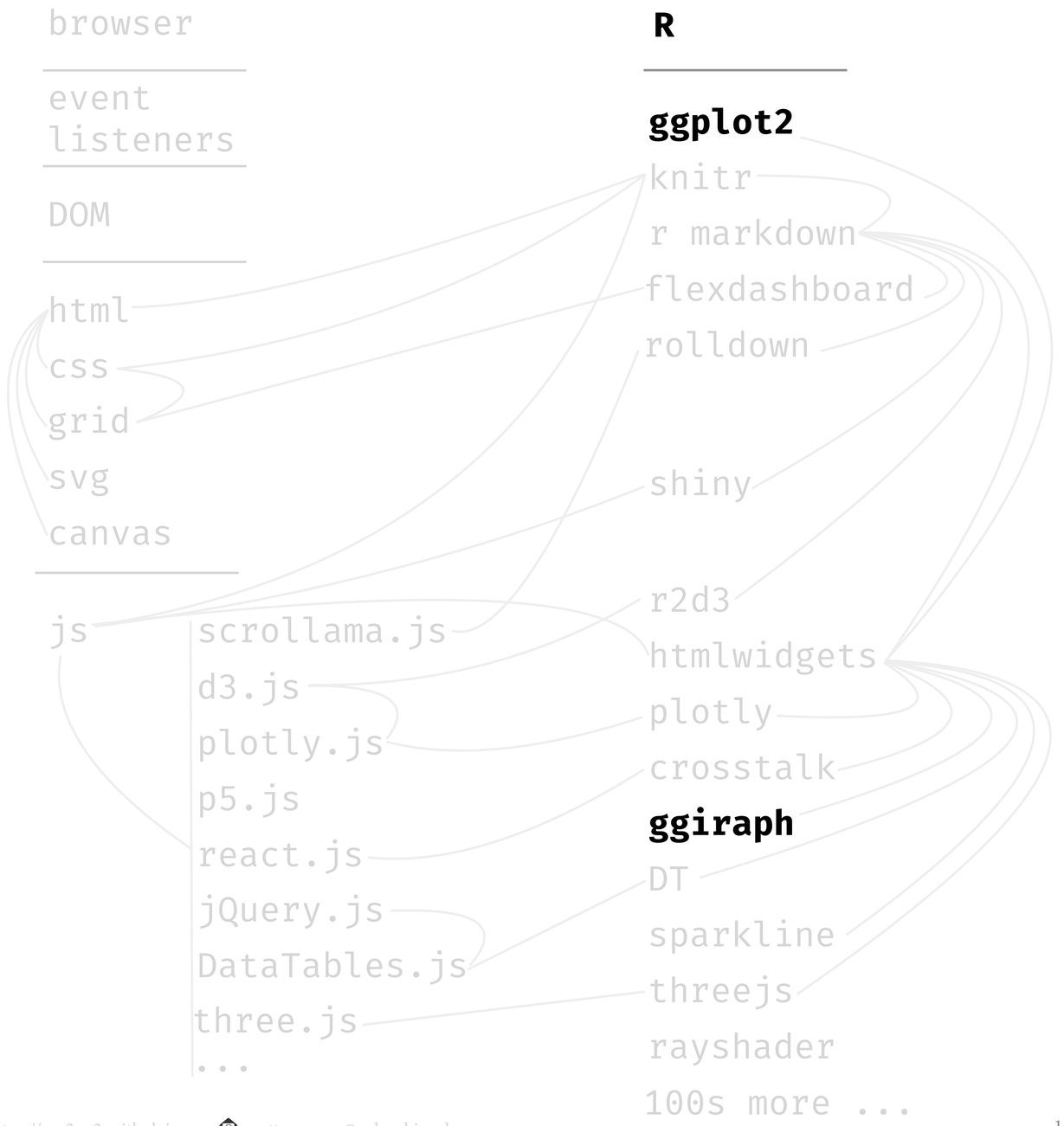
```
gg_boundaries <-
  ggplot() +
  theme_void() +
  coord_equal() +
  geom_path_interactive(
    data = filter(
      fields,
      is_infield == FALSE),
    mapping = aes(
      x = xsh,
      y = ysh,
      group = id,
      tooltip = id,
      data_id = id
      ),
    color = '#000000',
    alpha = 0.5) +

  geom_polygon(
    data = filter(
      fields,
      is_infield == TRUE),
    mapping = aes(
      x = xsh,
      y = ysh,
      group = id),
    fill = '#FAD9B4',
    color = '#FAD9B4')

girafe(
  code = print(gg_boundaries),
  options = list(
    opts_hover(
      css = 'stroke-width:3;'),
    opts_hover_inv(
      css = 'stroke-opacity:0.1;')
    )
  )
```

30 baseball outfields — an *interactive* version





tools for interactive content, several R packages transform ggplot2 into interactive graphics

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  ggplot() +
  theme_void() +
  coord_equal() +
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    data = filter(
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      is_infield == FALSE),
    mapping = aes(
      x = xsh,
      y = ysh,
      group = id,
      tooltip = id,
      data_id = id
      ),
    color = '#000000',
    alpha = 0.5) +

  geom_polygon(
    data = filter(
      fields,
      is_infield == TRUE),
    mapping = aes(
      x = xsh,
      y = ysh,
      group = id),
    fill = '#FAD9B4',
    color = '#FAD9B4')

girafe(
  code = print(gg_boundaries),
  options = list(
    opts_hover(
      css = 'stroke-width:3;'),
    opts_hover_inv(
      css = 'stroke-opacity:0.1;')
    )
  )
```

NOTICE THE ONE-TO-ONE MATCHUP WITH GGPLOT2 GEOMETRIES

DETAILS-ON-DEMAND: ADD INFORMATION TO SHOW IN THE TOOLTIP, SHOWN WHEN HOVERING

USED TO BIND ELEMENTS TO EVENT LISTENERS

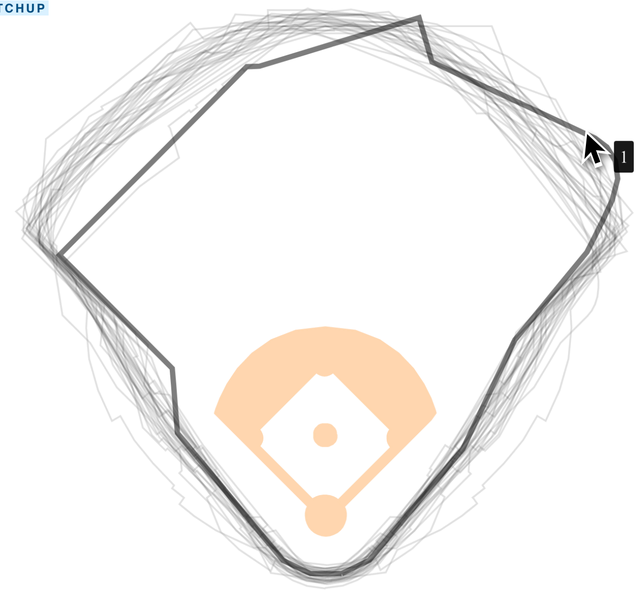
CHANGE PROPERTIES OF THINGS OF SHAPE REACTING TO HOVER

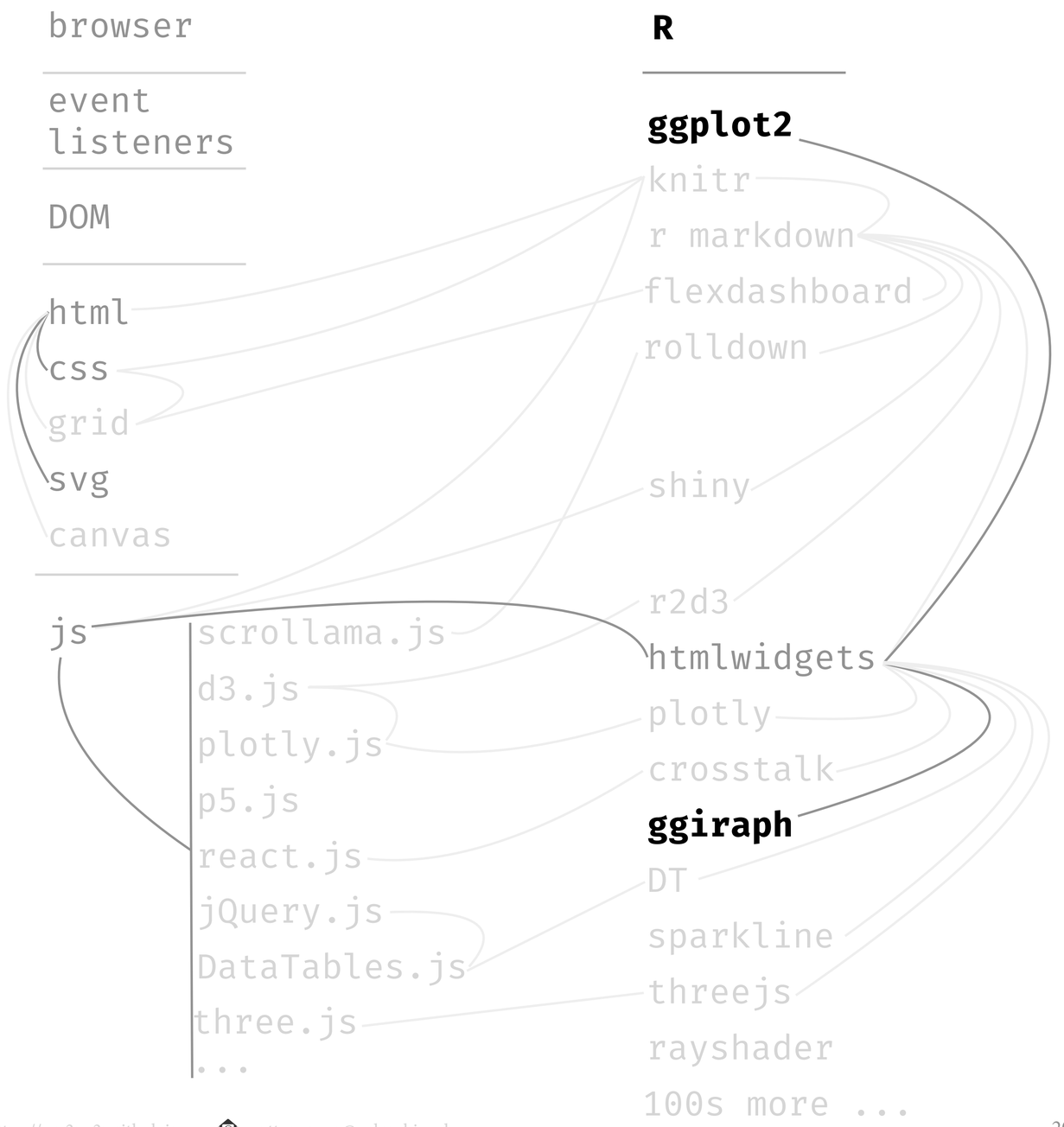
SET CSS PROPERTIES OF SHAPE; HERE STROKE-WIDTH

CHANGE PROPERTIES OF THINGS ELEMENT *NOT* REACTING TO HOVER

SET CSS PROPERTIES OF SHAPE; HERE STROKE-OPACITY

30 baseball outfields — an *interactive* version





tools for interactive content, several R packages transform ggplot2 into interactive graphics

ggplot2 + ggiraph

The **grammar of graphics** — implemented in R as ggplot2 — is among the most powerful coding libraries for creating static graphics. We've already seen how to use a complementary package with ggplot2 to add animation: gganimate, a grammar of animated graphics. With similar complementary packages, we can specify **interactivity**. Let's see a static version of a class example, the 30 baseball outfields, then make it interactive using ggiraph.

```
gg_fences <-
    ggplot() +
    theme_void() +
    theme( axis.text.x = element_text() ) +
    coord_equal() +
    scale_x_continuous(
      breaks = c(100, 300, 500),
      labels = c("Left Field",
                 "Center Field",
                 "Right Field")) +
    geom_path_interactive(
      data = fences,
      mapping = aes(
        x = xsh,
        y = -ysh,
        group = id,
        tooltip = id,
        data_id = id),
      color = 'black',
      alpha = 0.5)

girafe(
  code = print(gg_boundaries / gg_fences),
  options = list(
    opts_hover(
      css = 'stroke-width:3;'),
    opts_hover_inv(
      css = 'stroke-opacity:0.1;')
    )
  )
```

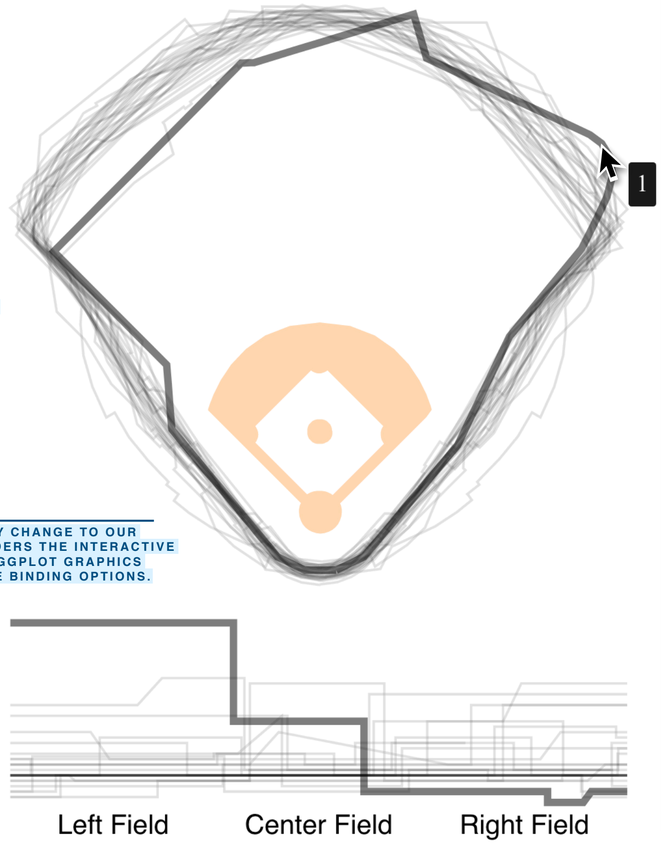
NOTICE THE SAME DATA ID USED HERE AS FOR THE OUTFIELD BOUNDARIES

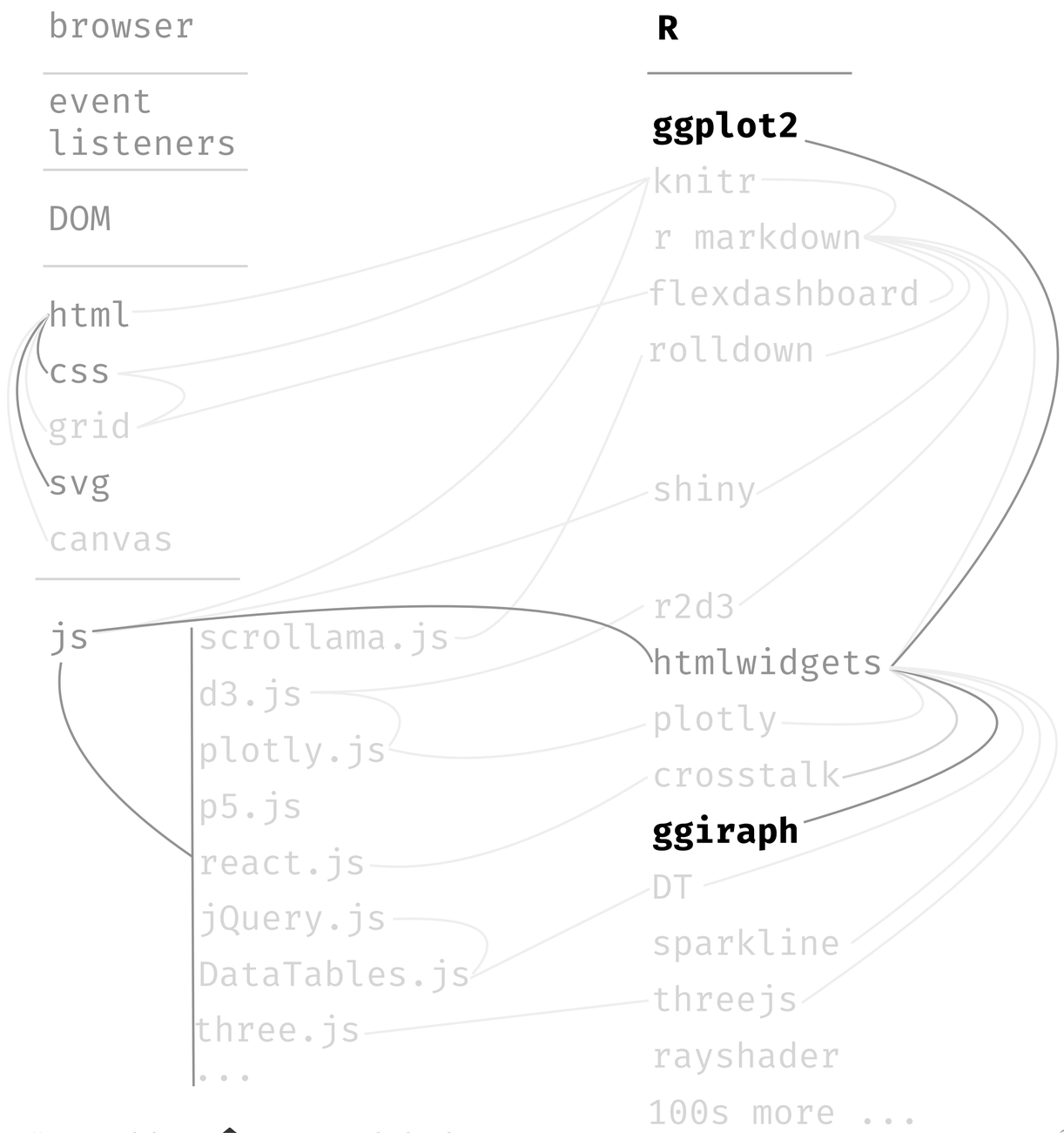
THIS IS THE ONLY CHANGE TO OUR CODE THAT RENDERS THE INTERACTIVE GRAPHIC. BOTH GGPLOT GRAPHICS SHARE THE SAME BINDING OPTIONS.

IN RSTUDIO, WE CAN SAVE THE INTERACTIVE GRAPHIC AS A STAND-ALONE WEB PAGE.

OR WE CAN INCLUDE THE CODE IN AN R MARKDOWN CHUNK OR FLEXDASHBOARD AND KNIT TO HTML.

30 baseball outfields — an *interactive* version





resources

References

Spencer, Scott. Sec. 3 In *Data in Wonderland*. 2021. https://ssp3nc3r.github.io/data_in_wonderland.

Attardi, Joe. *Modern CSS: Master the Key Concepts of CSS for Modern Web Development*, 2020. https://doi.org/10.1007/978-1-4842-6294-8.

Bellamy-Royds, Amelia, Kurt Cagle, and Dudley Storey. *Using SVG with CSS3 and HTML5 : Vector Graphics for Web Design*. O'Reilly, 2018.

Duckett, Jon. *HTML & CSS. Design and Build Websites*. Wiley, 2011.

Duckett, Jon, Gilles Ruppert, and Jack Moore. *JavaScript & JQuery: Interactive Front-End Web Development*. Indianapolis, IN: Wiley, 2014.

Fay, Colin, Vincent Guyader, Sebastien Rochette, and Girard Cervan. *Engineering Production-Grade Shiny Apps*. First edition. R Series. Boca Raton: CRC Press, 2021. https://engineering-shiny.org.

Gohel, David, and Panagiotis Skintzos. "*Ggiraph: Make 'ggplot2' Graphics Interactive*." Manual, 2021. https://davidgohel.github.io/ggiraph.

Janert, Philipp K. *D3 for the Impatient: Interactive Graphics for Programmers and Scientists*. First edition. Sebastopol, CA: O'Reilly Media, Inc, 2019.

Meeks, Elijah. *D3.Js in Action*. Second. Manning, 2018.

Murray, Scott. *Interactive Data Visualization for the Web*. Second. *An Introduction to Designing with D3*. O'Reilly, 2017.

Reas, Casey, and Ben Fry. *Processing A Programming Handbook for Visual Designers and Artists*. Second. The MIT Press, 2014.

Sievert, Carson. *Interactive Web-Based Data Visualization with R, Plotly, and Shiny*. Boca Raton, FL: CRC Press, Taylor and Francis Group, 2020. https://plotly-r.com.

Vaidyanathan, Ramnath, Yihui Xie, JJ Allaire, Joe Cheng, Carson Sievert, and Kenton Russell. "*Htmlwidgets: HTML Widgets for r.*" Manual, 2020. https://CRAN.R-project.org/package=htmlwidgets; main introduction: http://www.htmlwidgets.org.

Wickham, Hadley. "*Create Elegant Data Visualisations Using the Grammar of Graphics • Ggplot2*." Accessed February 26, 2021. https://ggplot2.tidyverse.org/.