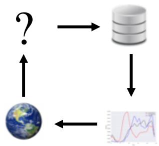
Data 100
Lecture 9:
Scraping Web Technologies

Slides by:
Joseph E. Gonzalez, Deb Nolan
deborah_nolan@berkeley.edu
hellerstein@berkeley.edu



Last Week …

Visualization

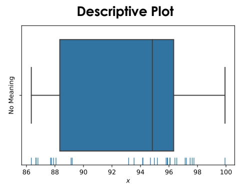
- Tools and Technologies
  - Maplotlib and seaborn
- Concepts
  - Length, color, and faceting
- Kinds of visualizations
  - Bar plots, histograms, rug plots, box plots, violin plot, scatter plots, and kernel density estimators
- Good vs bad visualizations
- Smoothing …

Kernel Density Estimates and Smoothing

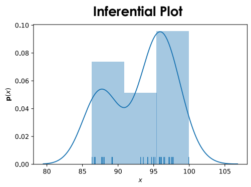
Kernel Density Estimators

- Inferential statistics – **estimate** properties of the population
  - Draw conclusions beyond the data…

Descriptive Plot



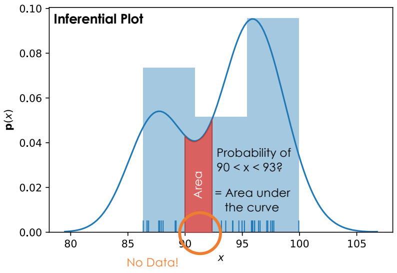
Inferential Plot

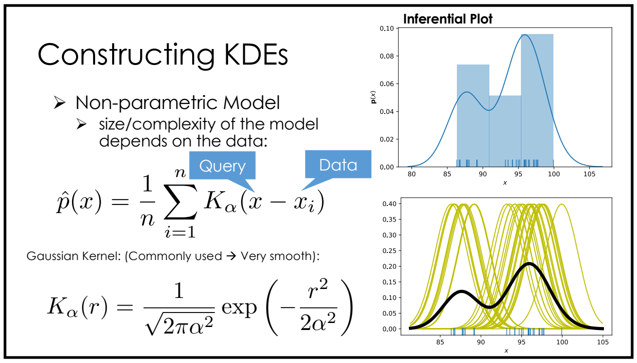


- Inferential statistics – **estimate** properties of the population
  - Draw conclusions beyond the data…

Suppose this data was constructed by a **random sample** of student grades?

What is the probability that the next student's grade will be between 90 and 93?





Constructing KDEs

- Non-parametric Model
  - size/complexity of the model depends on the data:

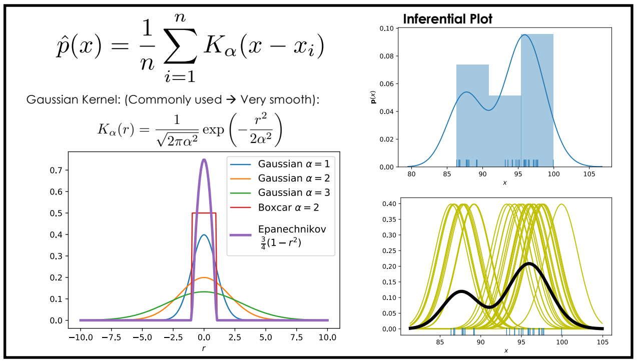
$$\hat{p}(x) = \frac{1}{n}\sum_{i=1}^{n} K_\alpha(x - x_i)$$

Query

Data

Gaussian Kernel: (Commonly used → Very smooth):

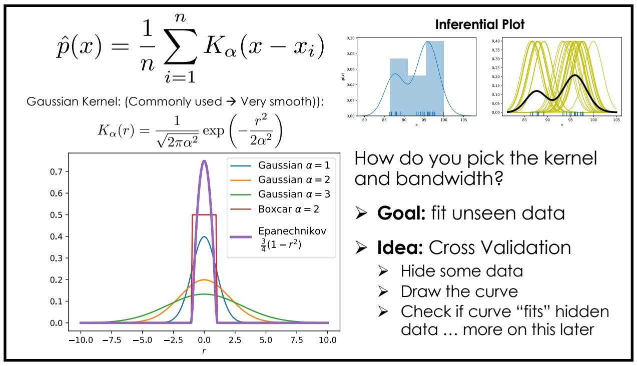
$$K_\alpha(r) = \frac{1}{\sqrt{2\pi\alpha^2}} \exp\left(-\frac{r^2}{2\alpha^2}\right)$$



$$\hat{p}(x) = \frac{1}{n}\sum_{i=1}^{n} K_\alpha(x - x_i)$$

Gaussian Kernel: (Commonly used → Very smooth):

$$K_\alpha(r) = \frac{1}{\sqrt{2\pi\alpha^2}} \exp\left(-\frac{r^2}{2\alpha^2}\right)$$



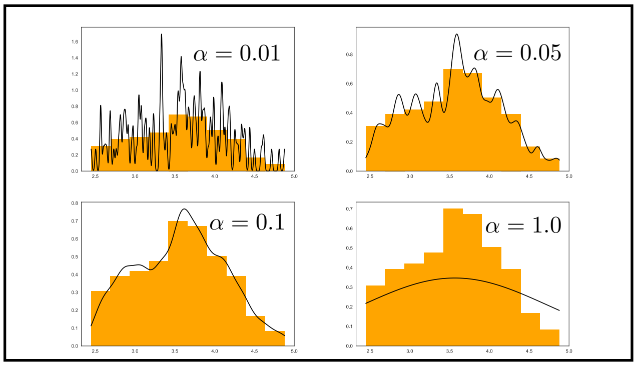
$$\hat{p}(x) = \frac{1}{n}\sum_{i=1}^{n} K_\alpha(x - x_i)$$

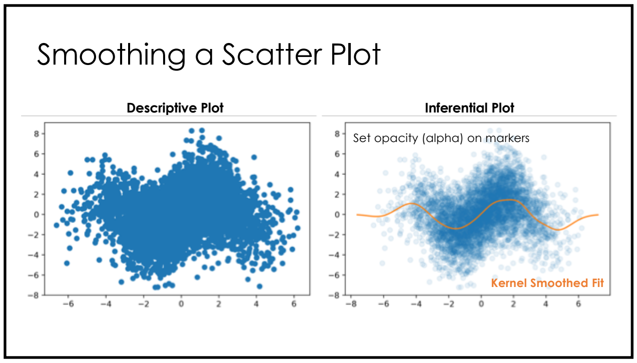
Gaussian Kernel: (Commonly used → Very smooth)):

$$K_\alpha(r) = \frac{1}{\sqrt{2\pi\alpha^2}} \exp\left(-\frac{r^2}{2\alpha^2}\right)$$

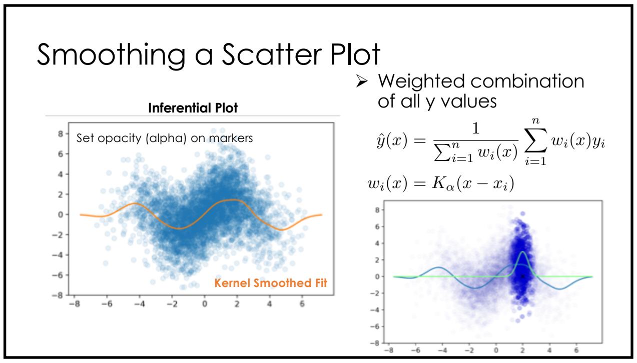
How do you pick the kernel and bandwidth?

- **Goal:** fit unseen data
- **Idea:** Cross Validation
  - Hide some data
  - Draw the curve
  - Check if curve "fits" hidden data … more on this later





Smoothing a Scatter Plot

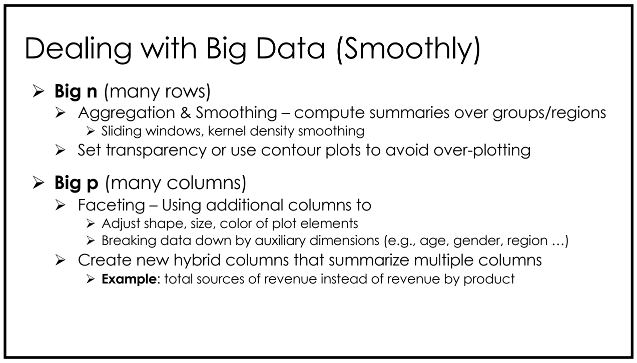


Smoothing a Scatter Plot

- Weighted combination of all y values

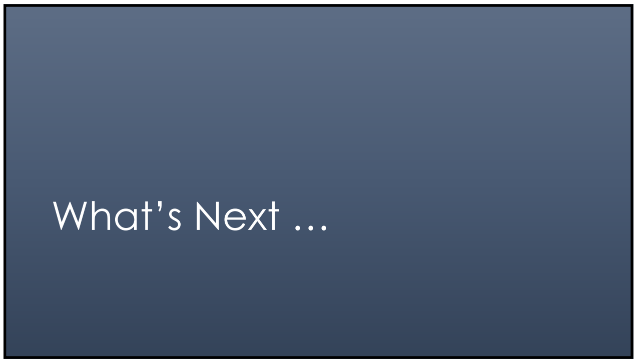
$$\hat{y}(x) = \frac{1}{\sum_{i=1}^{n} w_i(x)} \sum_{i=1}^{n} w_i(x) y_i$$

$$w_i(x) = K_\alpha(x - x_i)$$

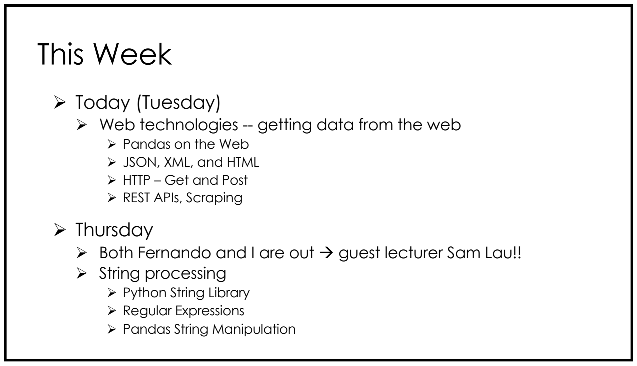


Dealing with Big Data (Smoothly)

- **Big n** (many rows)
  - Aggregation & Smoothing – compute summaries over groups/regions
    - Sliding windows, kernel density smoothing
  - Set transparency or use contour plots to avoid over-plotting
- **Big p** (many columns)
  - Faceting – Using additional columns to
    - Adjust shape, size, color of plot elements
    - Breaking data down by auxiliary dimensions (e.g., age, gender, region …)
  - Create new hybrid columns that summarize multiple columns
    - **Example:** total sources of revenue instead of revenue by product



What's Next …

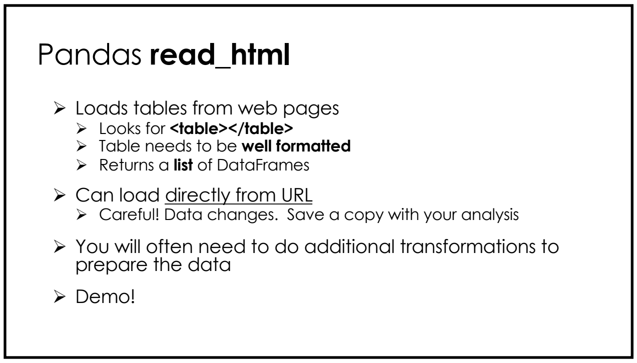


This Week

- Today (Tuesday)
  - Web technologies -- getting data from the web
    - Pandas on the Web
    - JSON, XML, and HTML
    - HTTP – Get and Post
    - REST APIs, Scraping
- Thursday
  - Both Fernando and I are out → guest lecturer Sam Lau!!
  - String processing
    - Python String Library
    - Regular Expressions
    - Pandas String Manipulation

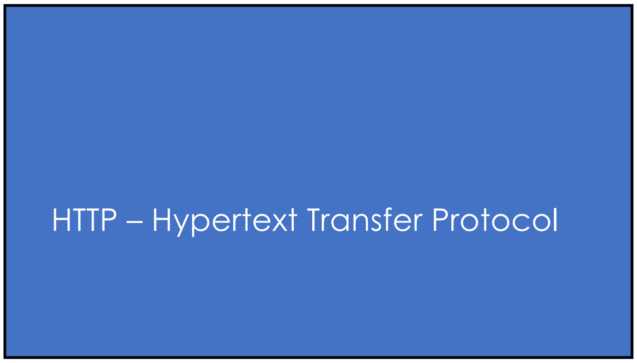
Getting Data from the Web

Starting Simple with Pandas



Pandas **read_html**

- Loads tables from web pages
  - Looks for **<table></table>**
  - Table needs to be **well formatted**
  - Returns a **list** of DataFrames
- Can load directly from URL
  - Careful! Data changes. Save a copy with your analysis
- You will often need to do additional transformations to prepare the data
- Demo!

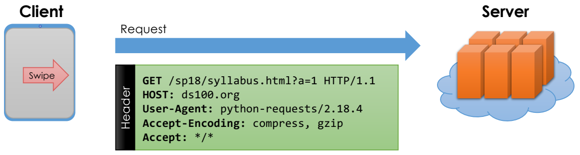


HTTP – Hypertext Transfer Protocol

HTTP
Hypertext Transfer Protocol

- Created at CERN by Tim Berners-Lee in 1989 as part of the World Wide Web
- Started as a simple ***request-response* protocol** used by web servers and browsers to access hypertext
- Widely used exchange data and provides services:
  - Access webpage & submit forms
  - Common API to data and services across the internet
- Foundation of modern REST APIs … (more on this soon)

Request – Response Protocol



```
GET /sp18/syllabus.html?a=1 HTTP/1.1
HOST: ds100.org
User-Agent: python-requests/2.18.4
Accept-Encoding: compress, gzip
Accept: */*
```

First line contains:

`GET /sp18/syllabus.html?a=1 HTTP/1.1`

- a method, e.g., GET or POST
- a URL or path to the document
- the protocol and its version

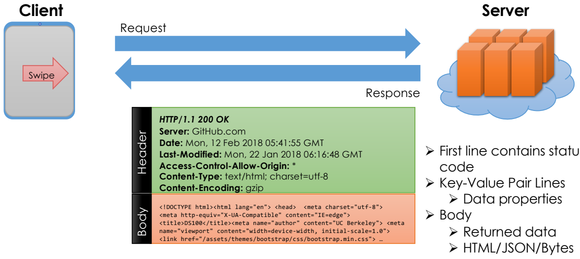
Remaining Header Lines

- Key-value pairs
- Specify a range of attributes

Optional Body

- send extra parameters & data

Request – Response Protocol

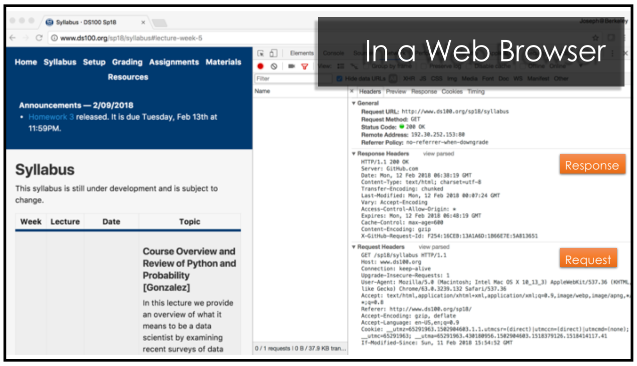


HTTP/1.1 200 OK
Server: GitHub.com
Date: Mon, 12 Feb 2018 05:41:55 GMT
Last-Modified: Mon, 22 Jan 2018 06:16:48 GMT
Access-Control-Allow-Origin: *
Content-Type: text/html; charset=utf-8
Content-Encoding: gzip

```
<!DOCTYPE html><html lang="en"> <head>  <meta charset="utf-8">
<meta http-equiv="X-UA-Compatible" content="IE=edge">
<title>DS100</title><meta name="author" content="UC Berkeley"> <meta
name="viewport" content="width=device-width, initial-scale=1.0">
<link href="/assets/themes/bootstrap/css/bootstrap.min.css"> …
```

- First line contains status code
- Key-Value Pair Lines
  - Data properties
- Body
  - Returned data
  - HTML/JSON/Bytes

In a Web Browser


Syllabus · DS100 Sp18
www.ds100.org/sp18/syllabus#lecture-week-5
Home Syllabus Setup Grading Assignments Materials Resources
Elements
Filter
Name
Headers Preview Response Cookies Timing
Response
Request
0 / 1 requests | 0 B / 37.9 KB tran...

Announcements — 2/09/2018
- Homework 3 released. It is due Tuesday, Feb 13th at 11:59PM.

Syllabus

This syllabus is still under development and is subject to change.

Week	Lecture	Date	Topic
			Course Overview and Review of Python and Probability [Gonzalez] In this lecture we provide an overview of what it means to be a data scientist by examining recent surveys of data

```
▼ General
   Request URL: http://www.ds100.org/sp18/syllabus
   Request Method: GET
   Status Code: ● 200 OK
   Remote Address: 192.30.252.153:80
   Referrer Policy: no-referrer-when-downgrade
▼ Response Headers     view parsed
   HTTP/1.1 200 OK
   Server: GitHub.com
   Date: Mon, 12 Feb 2018 06:38:19 GMT
   Content-Type: text/html; charset=utf-8
   Transfer-Encoding: chunked
   Last-Modified: Mon, 12 Feb 2018 00:07:24 GMT
   Vary: Accept-Encoding
   Access-Control-Allow-Origin: *
   Expires: Mon, 12 Feb 2018 06:48:19 GMT
   Cache-Control: max-age=600
   Content-Encoding: gzip
   X-GitHub-Request-Id: F254:16CEB:13A1A6D:1866E7E:5A813651
▼ Request Headers     view parsed
   GET /sp18/syllabus HTTP/1.1
   Host: www.ds100.org
   Connection: keep-alive
   Upgrade-Insecure-Requests: 1
   User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_13_3) AppleWebKit/537.36 (KHTML,
   like Gecko) Chrome/63.0.3239.132 Safari/537.36
   Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/apng,*/
   *;q=0.8
   Referer: http://www.ds100.org/sp18/
   Accept-Encoding: gzip, deflate
   Accept-Language: en-US,en;q=0.9
   Cookie: __utmz=65291963.1502904603.1.1.utmcsr=(direct)|utmccn=(direct)|utmcmd=(none);
   __utmc=65291963; __utma=65291963.430180956.1502904603.1518379126.1518414117.41
   If-Modified-Since: Sun, 11 Feb 2018 15:54:52 GMT
```

Request Types (Main Types)

- **GET** – *get information*
  - Parameters passed in URI (limited to ~2000 characters)
    - `/app/user_info.json?username=`***`mejoeyg`***`&version=`***`now`***
    - Request body is typically ignored
  - Should not have side-effects (e.g., update user info)
  - Can be cached in on server, network, or in browser (bookmarks)
  - Related requests: HEAD, OPTIONS
- **POST** – *send information*
  - Parameters passed in URI and BODY
  - May and typically will have side-effects
  - Often used with web forms.
  - Related requests: PUT, DELETE

Response Status Codes

- **100s Informational** – Communication continuing, more input expected from client or server
- **200 Success** - e.g., 200 - general success;
- **300s Redirection or Conditional Action** – requested URL is located somewhere else.
- **400s Client Error**
  - 404 indicates the document was not found
  - 403 indicates that the server understood the request but refuses to authorize it
- **500s Internal Server Error or Broken Request** – error on the server side

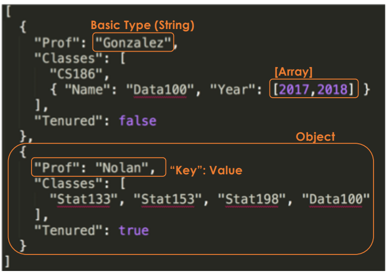
HTML, XML, and JSON

data formats of the web

HTML/XML/JSON

- ➢ Most services will exchange data in HTML, XML, or JSON
- ➢ Why?
  - ➢ Descriptive
    - ➢ Can maintain meta-data
  - ➢ Extensible
    - ➢ Organization can change and maintain compatibility
  - ➢ Human readable
    - ➢ Useful for debugging and provides a common interface
  - ➢ Machine readable
    - ➢ A wide range of technologies for parsing

JSON: JavaScript Object Notation

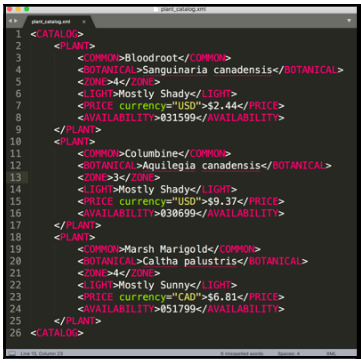


```
[
  {
    "Prof": "Gonzalez",
    "Classes": [
      "CS186",
      { "Name": "Data100", "Year": [2017,2018] }
    ],
    "Tenured": false
  },
  {
    "Prof": "Nolan",
    "Classes": [
      "Stat133", "Stat153", "Stat198", "Data100"
    ],
    "Tenured": true
  }
]
```

- ➢ Recursive datatype
  - ➢ Data inside of data
- ➢ **Value** is a:
  - ➢ A basic type:
    - ➢ String
    - ➢ Number
    - ➢ true/false
    - ➢ Null
  - ➢ Array of **Values**
  - ➢ A dictionary of *key*:**Value** pairs
- ➢ Demo Notebook

XML and HTML

eXtensible Markup Language



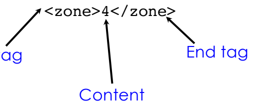
```
<CATALOG>
    <PLANT>
        <COMMON>Bloodroot</COMMON>
        <BOTANICAL>Sanguinaria canadensis</BOTANICAL>
        <ZONE>4</ZONE>
        <LIGHT>Mostly Shady</LIGHT>
        <PRICE currency="USD">$2.44</PRICE>
        <AVAILABILITY>031599</AVAILABILITY>
    </PLANT>
    <PLANT>
        <COMMON>Columbine</COMMON>
        <BOTANICAL>Aquilegia canadensis</BOTANICAL>
        <ZONE>3</ZONE>
        <LIGHT>Mostly Shady</LIGHT>
        <PRICE currency="USD">$9.37</PRICE>
        <AVAILABILITY>030699</AVAILABILITY>
    </PLANT>
    <PLANT>
        <COMMON>Marsh Marigold</COMMON>
        <BOTANICAL>Caltha palustris</BOTANICAL>
        <ZONE>4</ZONE>
        <LIGHT>Mostly Sunny</LIGHT>
        <PRICE currency="CAD">$6.81</PRICE>
        <AVAILABILITY>051799</AVAILABILITY>
    </PLANT>
<CATALOG>
```

XML is a standard for *semantic, hierarchical* representation of data

Syntax : **Element / Node**

The basic unit of XML code is called an “element” or “node”

Each Node has a start tag and end tag

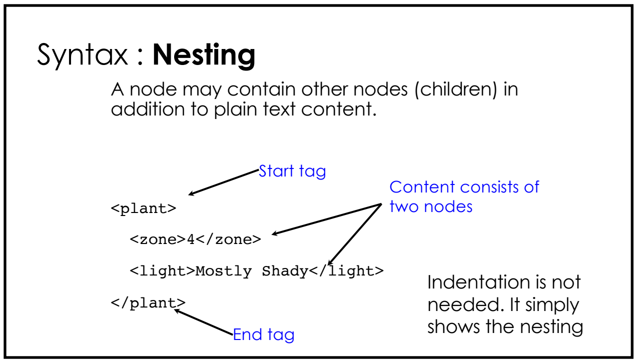


<zone>4</zone>

Start tag

End tag

Content



Syntax : **Nesting**

A node may contain other nodes (children) in addition to plain text content.

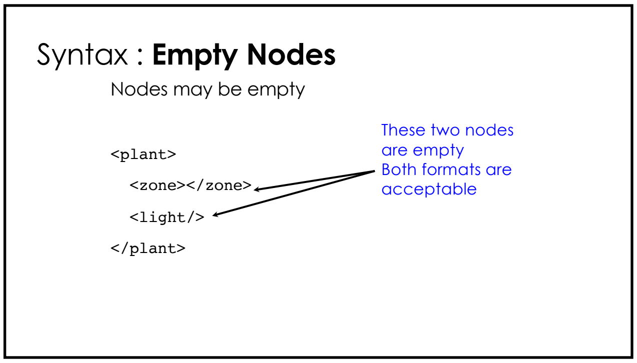
```
<plant>
  <zone>4</zone>
  <light>Mostly Shady</light>
</plant>
```

Start tag

Content consists of two nodes

End tag

Indentation is not needed. It simply shows the nesting

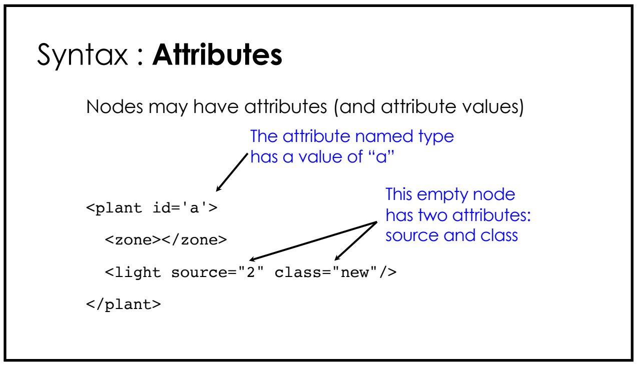


Syntax : **Empty Nodes**

Nodes may be empty

```
<plant>
  <zone></zone>
  <light/>
</plant>
```

These two nodes are empty
Both formats are acceptable



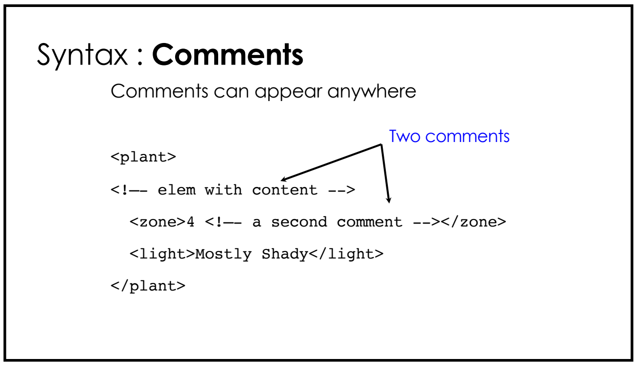
Syntax : **Attributes**

Nodes may have attributes (and attribute values)

```
<plant id='a'>
  <zone></zone>
  <light source="2" class="new"/>
</plant>
```

The attribute named type has a value of “a”

This empty node has two attributes: source and class

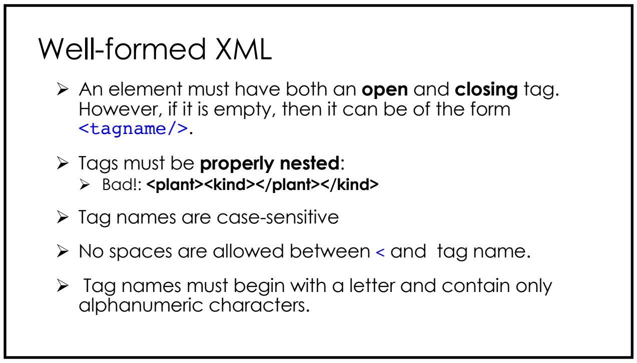


Syntax : **Comments**

Comments can appear anywhere

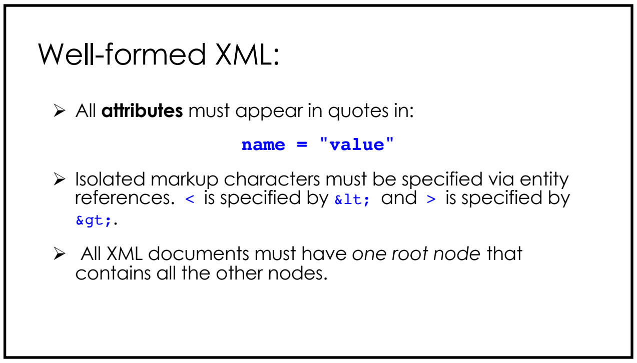
```
<plant>
<!-- elem with content -->
  <zone>4 <!-- a second comment --></zone>
  <light>Mostly Shady</light>
</plant>
```

Two comments



Well-formed XML

- An element must have both an **open** and **closing** tag. However, if it is empty, then it can be of the form `<tagname/>`.
- Tags must be **properly nested**:
  - Bad!: **<plant><kind></plant></kind>**
- Tag names are case-sensitive
- No spaces are allowed between < and tag name.
- Tag names must begin with a letter and contain only alphanumeric characters.



Well-formed XML:

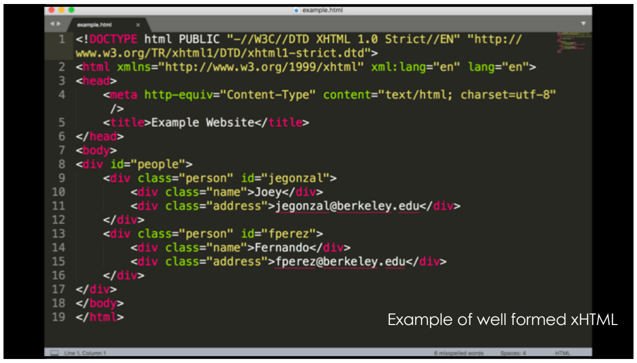
- All **attributes** must appear in quotes in:

  `name = "value"`

- Isolated markup characters must be specified via entity references. < is specified by `&lt;` and > is specified by `&gt;`.
- All XML documents must have *one root node* that contains all the other nodes.

xHTML: Extensible Hypertext Markup Language

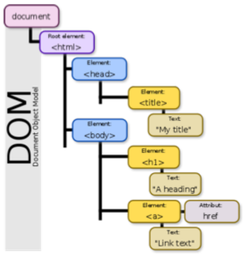
- HTML is an XML-"like" structure → Pre-dated XML
  - HTML is often not well-formed, which makes it difficult to parse and locate content,
  - Special parsers "fix" the HTML to make it well-formed
    - Results in even worse HTML
- xHTML was introduced to bridge HTML and XML
  - Adopted by many webpages
  - Can be easily parsed and queried by XML tools



```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN" "http://
www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en" lang="en">
<head>
    <meta http-equiv="Content-Type" content="text/html; charset=utf-8"
    />
    <title>Example Website</title>
</head>
<body>
<div id="people">
    <div class="person" id="jegonzal">
        <div class="name">Joey</div>
        <div class="address">jegonzal@berkeley.edu</div>
    </div>
    <div class="person" id="fperez">
        <div class="name">Fernando</div>
        <div class="address">fperez@berkeley.edu</div>
    </div>
</div>
</body>
</html>
```

Example of well formed xHTML

DOM: Document Object Model



- Treat XML and HTML as a Tree
  - Fits XML and well formed HTML
- Visual containment → children
- Manipulated dynamically using JavaScript
  - HTML DOM and actual DOM the browser shows may differ (substantially)
  - Parsing in Python → Selenium + Headless Chrome … (out of scope)

Tree terminology

- There is only one *root (AKA document node)* in the tree, and all other nodes are contained within it.
- We think of these other nodes as *descendants* of the root node.
- We use the language of a family tree to refer to relationships between nodes.
  - *parents, children, siblings, ancestors, descendants*
- The *terminal nodes* in a tree are also known as *leaf nodes*. Content always falls in a leaf node.

HTML trees: a few additional "rules"

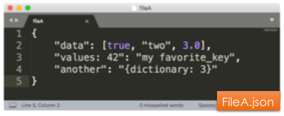
- Typically organized around `<div>` `</div>` elements
- Hyperlinks: `<a href="uri">Link Text</a>`
- The ***id*** attribute: unique key to identify an HTML node
  - Poorly written HTML → not always unique
- Older web forms will contain forms:

```
<form action="/submit_comment.php" method="post">
   <input type="text" name="comment" value="blank" />
   <input type="submit" value="Submit" />
</form>
```

See notebook for demo on working with forms …

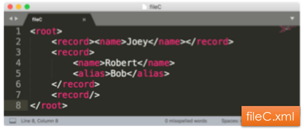
Which files are broken?

http://bit.ly/ds100-sp18-xml



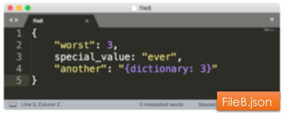
```
{
    "data": [true, "two", 3.0],
    "values: 42": "my favorite_key",
    "another": "{dictionary: 3}"
}
```

FileA.json



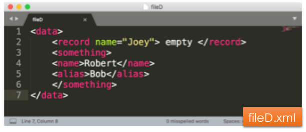
```
<root>
    <record><name>Joey</name></record>
    <record>
        <name>Robert</name>
        <alias>Bob</alias>
    </record>
    <record/>
</root>
```

fileC.xml



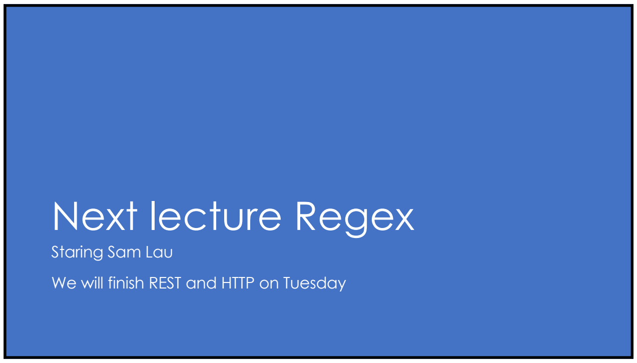
```
{
    "worst": 3,
    special_value: "ever",
    "another": "{dictionary: 3}"
}
```

FileB.json



```
<data>
    <record name="Joey"> empty </record>
    <something>
    <name>Robert</name>
    <alias>Bob</alias>
    </something>
</data>
```

fileD.xml



Next lecture Regex

Staring Sam Lau

We will finish REST and HTTP on Tuesday