

# CSci 127: Introduction to Computer Science



[hunter.cuny.edu/csci](http://hunter.cuny.edu/csci)

# Announcements



- Due to a rescheduled meeting, my office hours are moved (today only) to 12:30-1:30pm.  
Tutoring available: 9:30am-9:30pm  
Mondays-Friday in 1001E HN.

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Tutoring available: 9:30am-9:30pm  
Mondays-Friday in 1001E HN.
- Each lecture includes a survey of computing research and tech in NYC.

*Today: Prof. Katherine St. John  
(computational biology)*

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- Could you spend more time on circuits/logical expressions/truth tables/decisions?  
*We will do a bit today, but much more in the following weeks.*
- Is it okay to work ahead?  
*Yes! It's great to try things before lecture/lab (builds a "mental scaffold" to hold new material covered).*  
*All the labs are up for the rest of the semester, and programs open on gradescope 4 weeks before the deadline.*

# Today's Topics



- Recap: Logical Expressions & Circuits
- Design: Cropping Images
- Accessing Formatted Data
- CS Survey: Computational Biology

# Recap: Logical Operators

## and

in1	and	in2	<i>returns:</i>
False	and	False	False
False	and	True	False
True	and	False	False
True	and	True	True

# Recap: Logical Operators

**and**

in1	in2	<i>returns:</i>
False	and	False
False	and	True
True	and	False
True	and	True

**or**

in1	in2	<i>returns:</i>
False	or	False
False	or	True
True	or	False
True	or	True

# Recap: Logical Operators

**and**

in1		in2	<i>returns:</i>
False	and	False	False
False	and	True	False
True	and	False	False
True	and	True	True

**or**

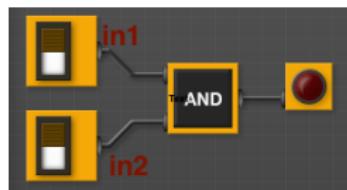
in1		in2	<i>returns:</i>
False	or	False	False
False	or	True	True
True	or	False	True
True	or	True	True

**not**

	in1	<i>returns:</i>
not	False	True
not	True	False

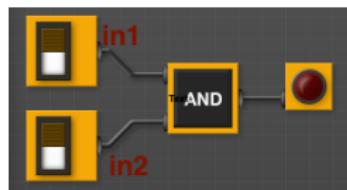
# Logical Operators & Circuits

- Each logical operator (and, or, & not) can be used to join together expressions.



# Logical Operators & Circuits

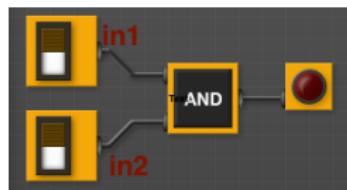
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Example:  $\text{in1} \text{ and } \text{in2}$

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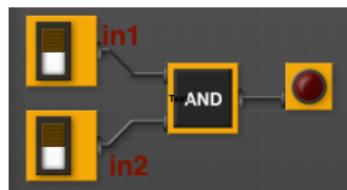


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# Logical Operators & Circuits

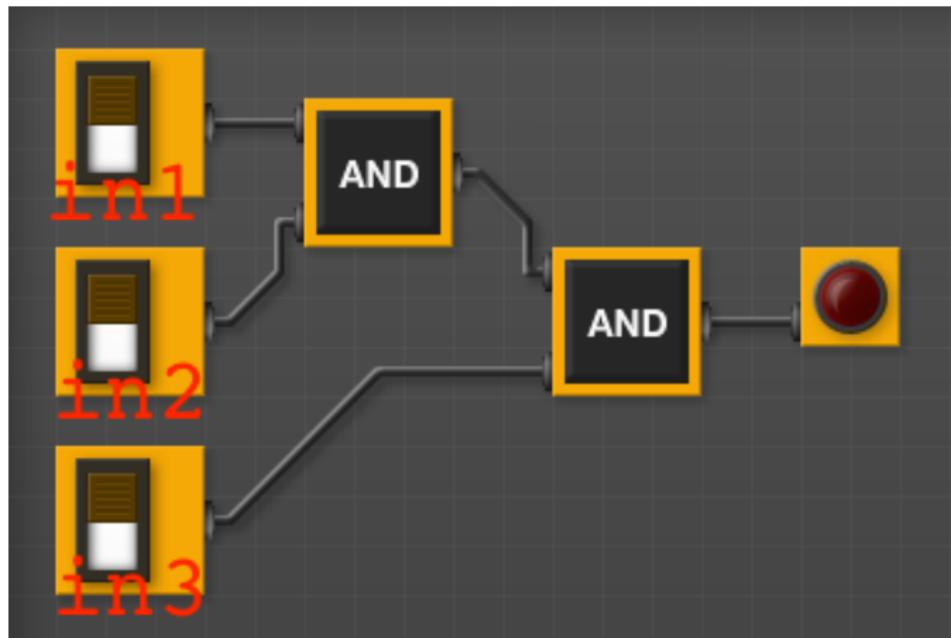
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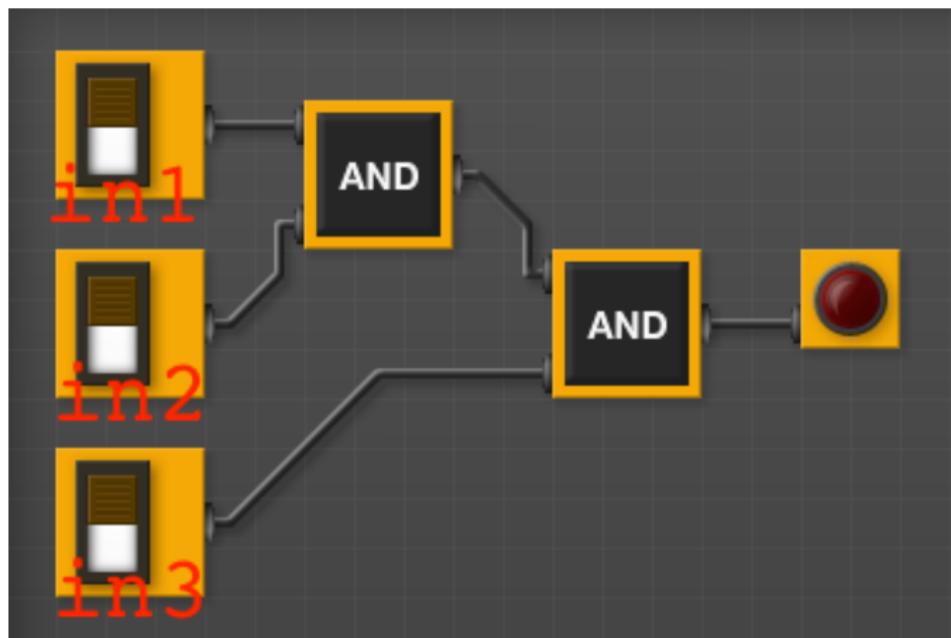
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## Examples: Logical Circuit



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$(\text{in1} \text{ and } \text{in2}) \text{ and } \text{in3}$

# Examples: Logical Expressions

*Examples from last lecture:*

```
origin = "Indian Ocean"
winds = 100
if (winds > 74):
    print("Major storm, called a ", end="")
    if origin == "Indian Ocean" or origin == "South Pacific":
        print("cyclone.")
    elif origin == "North Pacific":
        print("typhoon.")
    else:
        print("hurricane.")

visibility = 0.2
winds = 40
conditions = "blowing snow"
if (winds > 35) and (visibility < 0.25) and \
    (conditions == "blowing snow" or conditions == "heavy snow"):
    print("Blizzard!")
```

# In Pairs or Triples:

Predict what the code will do:

```
x = 6
y = x % 4
w = y**3
z = w // 2
print(x,y,w,z)
x,y = y,w
print(x,y,w,z)
x = y / 2
print(x,y,w,z)

sports = ["Field Hockey", "Swimming", "Water Polo"]
mess = "Qoauxca BrletRce crcx qvBnqa ocUxk"
result = ""
for i in range(len(mess)):
    if i % 3 == 0:
        print(mess[i])
        result = result + mess[i]
print(sports[1], result)
```

# Python Tutor

```
x = 6
y = x % 4
w = y**3
z = w // 2
print(x,y,w,z)      (Demo with pythonTutor)
x,y = y,w
print(x,y,w,z)
x = y / 2
print(x,y,w,z)
```

# In Pairs or Triples: Design Question

From Final Exam, Fall 2017, V4, #6.



Design an algorithm that reads in an image and displays the lower left corner of the image.

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**Input:**

**Output:**

**Process:** (*Brainstorm for a “To Do” list to accomplish this.*)

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  - ① Import libraries.
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img = plt.imread(inF) #Read in image from inF
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height = img.shape[0] #Get height  
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`img2 = img[height/2:, :width/2] #Crop to lower left corner`

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- ⑥ Display the new image.

```
plt.imshow(img2) #Load our new image into pyplot  
plt.show() #Show the image (waits until closed to continue)
```

# Structured Data

College	Undergraduate		
	Full-time	Part-time	Total
Baruch	11,288	3,922	15,210
Brooklyn	10,198	4,208	14,406
City	10,067	3,250	13,317
Hunter	12,223	4,500	16,723
John Jay	9,831	2,843	12,674
Lehman	6,600	4,720	11,320
Medgar Evers	4,760	2,059	6,819
NYCCT	10,912	6,370	17,282
Queens	11,693	4,633	16,326
Staten Island	9,584	2,948	12,532
York	5,066	3,192	8,258

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- Python has several ways to read in such data.

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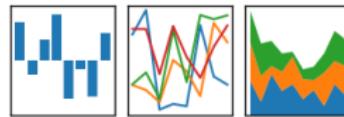
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- Python has several ways to read in such data.
- We will use the popular Python Data Analysis Library (**Pandas**).

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pandas

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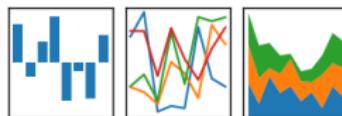


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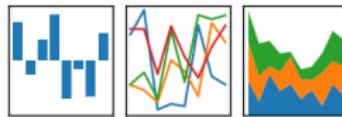


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- Open source and freely available (part of anaconda distribution).

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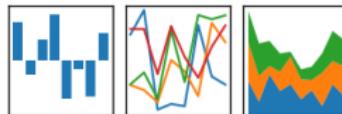


- We will use the popular Python Data Analysis Library (**Pandas**).
- Open source and freely available (part of anaconda distribution).
- Already loaded on the machines in 1001E North.

# Structured Data

pandas

$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$

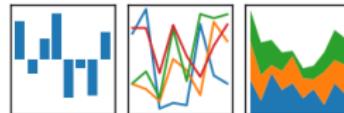


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- See end of Lab 6 for directions on downloading it to your home machine.

# Structured Data

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- We will use the popular Python Data Analysis Library (**Pandas**).
- Open source and freely available (part of anaconda distribution).
- Already loaded on the machines in 1001E North.
- See end of Lab 6 for directions on downloading it to your home machine.
- To use, add to the top of your file:

```
import pandas as pd
```

# CSV Files

College	Undergraduate		
	Full-time	Part-time	Total
Baruch	11,288	3,922	15,210
Brooklyn	10,198	4,208	14,406
City	10,067	3,250	13,317
Hunter	12,223	4,500	16,723
John Jay	9,831	2,843	12,674
Lehman	6,600	4,720	11,320
Medgar Evers	4,760	2,059	6,819
NYCCT	10,912	6,370	17,282
Queens	11,693	4,633	16,326
Staten Island	9,584	2,948	12,532
York	5,066	3,192	8,258

- Excel .xls files have much extra formatting.

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- The text file version is called **CSV** for comma separated values.

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- Each row is a line in the file.
- Columns are separated by commas on each line.

# CSV Files

Source: [https://en.wikipedia.org/wiki/Demographics\\_of\\_New\\_York\\_City](https://en.wikipedia.org/wiki/Demographics_of_New_York_City),  
All population figures are consistent with present-day boundaries.,,  
First census after the consolidation of the five boroughs.,,,

,,,,,,  
,,,,,,  
Year,Manhattan,Brooklyn,Queens,Bronx,Staten Island,Total  
1698,4937,2017,,,727,7681  
1771,21863,3623,,,2847,28423  
1790,33131,4549,6159,1781,3827,49447  
1800,60515,5740,6642,1755,4563,79215  
1810,96373,8303,7444,2267,5347,119734  
1820,123706,11187,8246,2782,6135,152056  
1830,202589,20535,9049,3023,7082,242278  
1840,312710,47613,14480,5346,10965,391114  
1850,515547,138882,18593,8032,15061,696115  
1860,813669,279122,32903,23593,25492,1174779  
1870,942292,419921,45468,37393,33029,1478103  
1880,1164673,599495,56559,51980,38991,1911698  
1890,1441216,838547,87050,88908,51693,2507414  
1900,1850093,1166582,152999,200507,67021,3437202  
1910,2331542,1634351,284041,430980,85969,4766883  
1920,2284103,2018356,469042,732016,116531,5620048  
1930,1867312,2560401,1079129,1265258,158346,6930446  
1940,1889924,2698285,1297634,1394711,174441,7454995  
1950,1960101,2738175,1550849,1451277,191555,7891957  
1960,1698281,2627319,1809578,1424815,221991,7781984  
1970,1539233,2602012,1986473,1471701,295443,7894862  
1980,1428285,2230936,1891325,1168972,352121,7071639  
1990,1487536,2300664,1951598,1203789,378977,7322564  
2000,1537195,2465326,2229379,1332650,443728,8008278  
2010,1585873,2504700,2230722,1385108,468730,8175133  
2015,1644518,2636735,2339150,1455444,474558,8550405

nycHistPop.csv

# Reading in CSV Files

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- To read in a CSV file: `myVar = pd.read_csv("myFile.csv")`

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- To read in a CSV file: `myVar = pd.read_csv("myFile.csv")`
- Pandas has its own type, **DataFrame**, that is perfect for holding a sheet of data.
- Often abbreviated: `df`.
- It also has **Series**, that is perfect for holding a row or column of data.

## Example: Reading in CSV Files

nycHistPop.csv

## In Lab 6

# Example: Reading in CSV Files

```
import matplotlib.pyplot as plt  
import pandas as pd
```

Source: [https://en.wikipedia.org/wiki/Demographics\\_of\\_New\\_York\\_City](https://en.wikipedia.org/wiki/Demographics_of_New_York_City),  
All population figures are consistent with present-day boundaries.....  
Five census after the consolidation of the five boroughs.....

.....  
Year,Manhattan,Brooklyn,Queens,Bronx,Staten Island,Total  
1690,4937,2037,...,727,7881  
1771,21843,36231,...,2847,28423  
1790,33131,4549,6159,1781,3827,49447  
1800,60515,5740,6442,1755,4543,75955  
1810,67541,6211,6811,2011,4973,85934  
1820,123704,11187,8246,2792,6135,152056  
1830,202589,20535,9049,3023,7082,242278  
1840,312110,18013,14041,5346,10965,391114  
1850,355441,21800,18891,5815,11581,501115  
1860,813469,279122,32903,23593,25492,174777  
1870,942292,419921,45468,37393,33029,1479103  
1880,1164473,59943,5653,51980,33091,1911801  
1890,1364473,72000,6581,58160,33091,2141134  
1900,185093,116582,152999,200507,67921,2437202  
1910,223342,1634351,2841,430980,8569,476683  
1920,2210103,2018354,44607,720201,11651,501088  
1930,1667113,1667113,1667113,1667113,1667113,4930446  
1940,1889924,2498285,1297634,1394711,174441,7454995  
1950,1960101,2738175,1550949,1451277,191555,7991957  
1960,1690311,1690311,1690311,1690311,1690311,781984  
1970,1539231,1460711,1471071,1471071,135443,769462  
1980,1426285,2230936,1891325,1168972,352121,7071639  
1990,1487536,2000664,1951598,1203789,378977,7322564  
2000,1537195,2485326,2223379,1332450,419728,8080879  
2010,1583873,2504705,2216722,1385108,419728,8175133  
2015,1444018,2646733,2339150,1459446,474558,8059405

nycHistPop.csv

In Lab 6

# Example: Reading in CSV Files

```
import matplotlib.pyplot as plt  
import pandas as pd
```

```
pop = pd.read_csv('nycHistPop.csv', skiprows=5)
```

```
Source: https://en.wikipedia.org/wiki/Demographics_of_New_York_City.....  
All population figures are consistent with present-day boundaries.....  
First census after the consolidation of the five boroughs.....  
.....  
Year,Bronx,Brooklyn,Queens,Bronx,Staten Island,Totals  
1690,4937,2037,727,788,1000  
1771,21843,3623,2847,28423  
1790,33131,4549,6159,1781,3827,49447  
1800,60515,5740,6442,1755,4543,75955  
1810,67000,62000,68000,18000,45000,109334  
1820,123704,11187,8246,2792,6135,152056  
1830,202589,20535,9049,3023,7082,242278  
1840,312110,18013,14000,5346,10965,391114  
1850,355400,218000,185000,5346,10965,50115  
1860,813449,279122,23903,23933,25492,174777  
1870,942292,419921,45468,37393,33029,1479103  
1880,1164473,599403,5653,51980,33021,1911801  
1890,1380000,720000,680000,5346,10965,2151134  
1900,1850593,116582,152999,200567,67621,2437202  
1910,2233142,1634351,2841,430980,8569,476683  
1920,22101103,2018354,44600,44600,73201,11651,501088  
1930,26711103,2018354,44600,44600,73201,11651,501088  
1940,1889924,2498285,1297634,1394711,174441,7454995  
1950,1960101,2738175,1550949,1451277,191555,7991957  
1960,1690000,2319319,1809000,1451277,191555,7981984  
1970,1539231,2465701,1472701,1235443,7981984  
1980,1428285,2230936,1891325,1168972,352121,7071639  
1990,1487536,2300664,1951598,1302789,378977,7322564  
2000,1537195,2485326,2223379,1332450,419728,8080879  
2010,1583873,2504705,2272722,1385108,419728,8175133  
2015,1444518,2642733,2339150,1459444,474558,8059405
```

nycHistPop.csv

In Lab 6

# Example: Reading in CSV Files

```
import matplotlib.pyplot as plt
import pandas as pd

pop = pd.read_csv('nycHistPop.csv', skiprows=5)
```

```
Source: https://en.wikipedia.org/wiki/Demographics_of_New_York_City.....  
All population figures are consistent with present-day boundaries.....  
First census after the consolidation of the five boroughs.....  
.....  
Year,Population  
1698,203,2037,...,727,7181  
1771,21843,36232,...,2847,28423  
1790,33131,4549,6159,1781,3827,49447  
1800,60515,5740,6442,1755,4543,75955  
1810,69101,5349,6135,1755,4543,75934  
1820,123704,11187,8246,2792,6135,152056  
1830,20589,20535,9049,3032,7082,242278  
1840,311510,110113,14045,5348,10965,391114  
1850,355441,128000,14850,5348,10965,391115  
1860,813469,279122,32903,23593,25492,174777  
1870,942292,419921,45468,37393,33029,1479103  
1880,1164473,59943,5653,51980,33029,1911801  
1890,1380000,718000,68000,51980,33029,1911814  
1900,1850093,116582,152999,200567,67621,2437202  
1910,2233142,1634351,2841,430980,8569,476683  
1920,22101103,2018354,44607,72021,11651,50048  
1930,18671112,1796128,1796128,15821,50048,4930446  
1940,1889924,2698285,1297634,1394711,174441,7454995  
1950,1960101,2738175,1550949,1451277,191555,7991957  
1960,1696010,1696010,1696010,1696010,1696010,781984  
1970,1539231,1465701,1471701,1471701,135443,768460  
1980,1426285,2230936,1891325,1168972,352121,7071639  
1990,1487536,2300664,1951598,1203789,378977,7322564  
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2015,1444518,2546733,2339150,1459446,474558,815133
```

nycHistPop.csv

In Lab 6

# Example: Reading in CSV Files

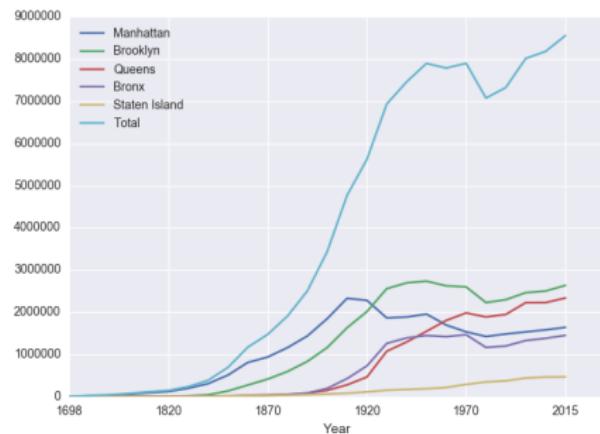
```
import matplotlib.pyplot as plt  
import pandas as pd
```

```
pop = pd.read_csv('nycHistPop.csv', skiprows=5)
```

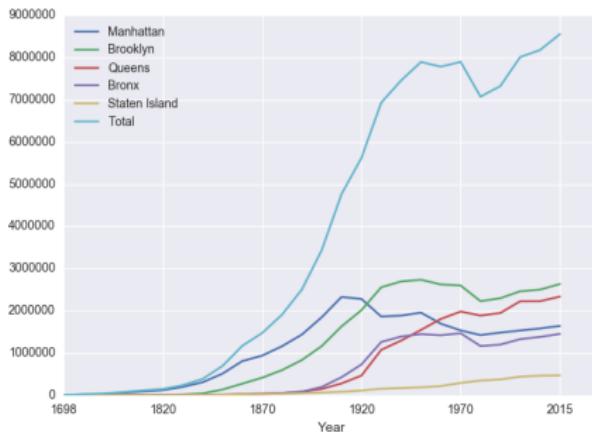
```
Source: https://en.wikipedia.org/wiki/Demographics_of_New_York_City.....  
All population figures are consistent with present-day boundaries.....  
First census after the consolidation of the five boroughs.....  
.....  
Year,Borough,Population  
1699,Manhattan, Brooklyn, Queens, Bronx, Staten Island, Total  
1771,21843,36231,2847,28423  
1790,33131,4549,6159,1781,3827,49447  
1800,60515,5740,6442,1755,4543,75935  
1810,67531,5549,6241,1755,4543,79334  
1820,123704,11487,8246,2792,6135,152056  
1830,202589,20535,9049,3023,7082,242278  
1840,312110,18013,14049,5348,10965,391114  
1850,355491,21803,18859,5835,11515,45154  
1860,613469,279122,32903,23593,25492,174777  
1870,942292,419921,45468,37393,33029,1479103  
1880,1164473,59943,5653,51980,33091,1911801  
1890,1362111,70001,6500,57000,35001,20000134  
1900,1850993,1165852,152999,200567,67921,2437202  
1910,233142,1634351,2841,430980,85869,476683  
1920,2210103,2018354,44601,44601,73201,11651,50048  
1930,2667111,2490128,35254,35254,55821,55821,6030446  
1940,1889924,2690285,1297634,1394711,174441,7454995  
1950,1960101,2738175,1550849,1451277,191555,7991957  
1960,1696011,2630235,1489001,1489001,1489001,1489001,781984  
1970,1539231,2465701,1472701,1472701,1472701,1472701,784640  
1980,1426285,2230936,11891325,1168972,152121,7071639  
1990,1487536,2300664,1951598,1203789,378977,7322564  
2000,1537195,2485326,2229379,1332450,413728,8080879  
2010,1583873,2504705,2216722,1385108,413728,8175133  
2015,1444518,2636733,2339150,1459446,474558,8059405
```

nycHistPop.csv

In Lab 6

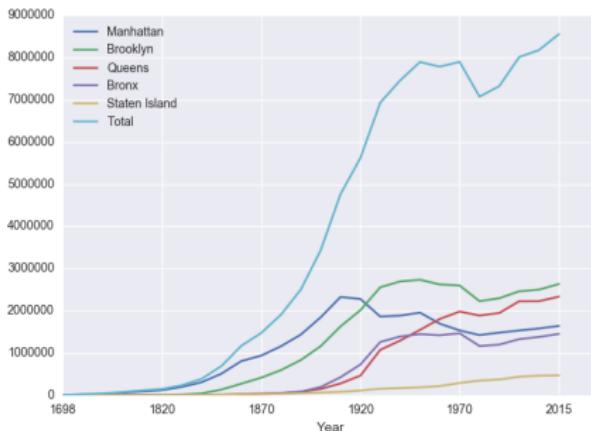


# Series in Pandas



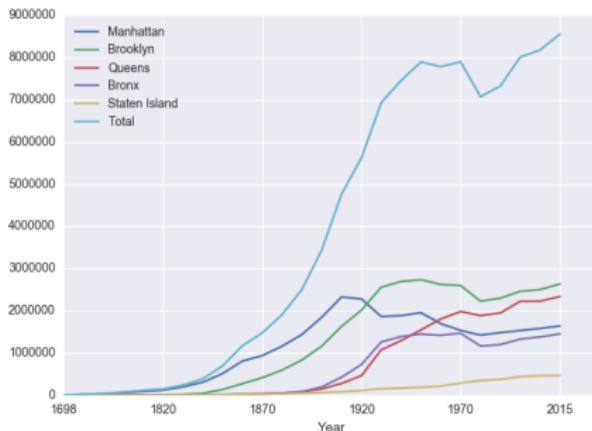
- Series can store a column or row of a DataFrame.

# Series in Pandas



- Series can store a column or row of a DataFrame.
- Example: `pop["Manhattan"]` is the Series corresponding to the column of Manhattan data.

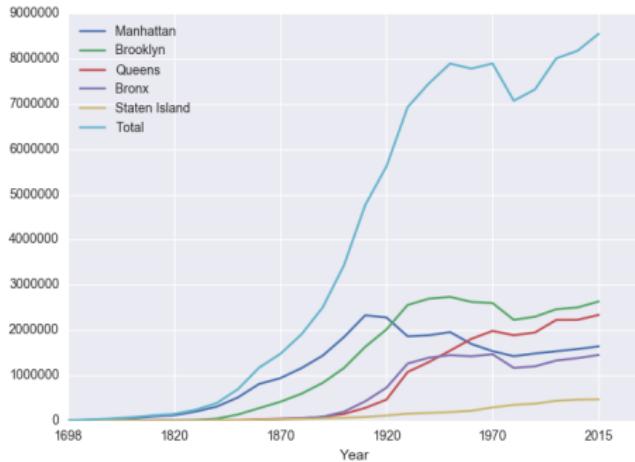
# Series in Pandas



- Series can store a column or row of a DataFrame.
- Example: `pop["Manhattan"]` is the Series corresponding to the column of Manhattan data.
- Example:  

```
print("The largest number living in the Bronx is",
      pop["Bronx"].max())
```

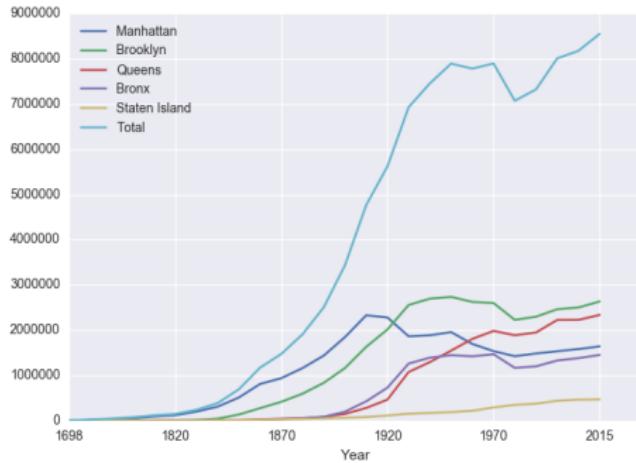
# In Pairs or Triples



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`

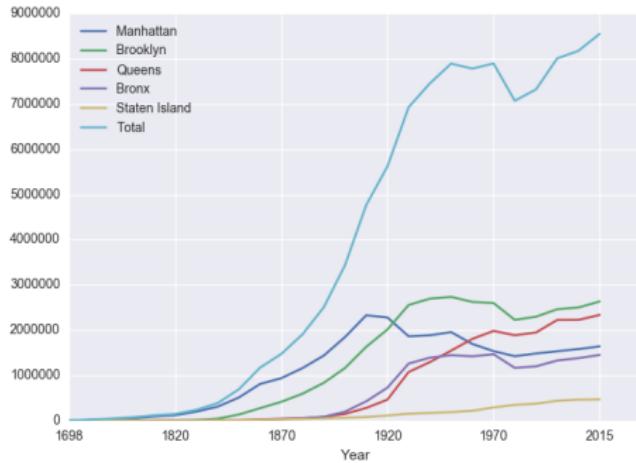
# In Pairs or Triples



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`

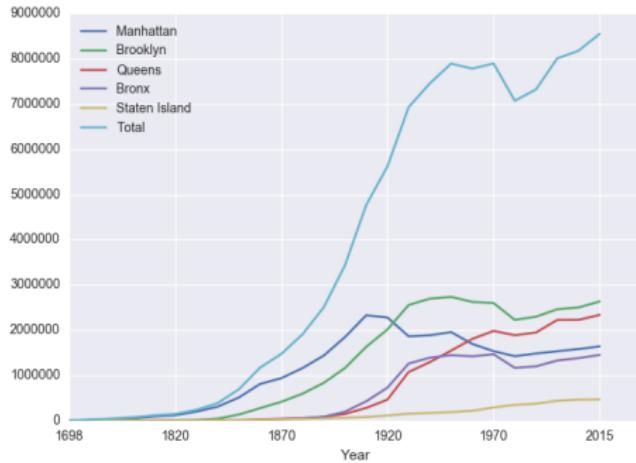
# In Pairs or Triples



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`
- `print("S I:", pop["Staten Island"].std())`

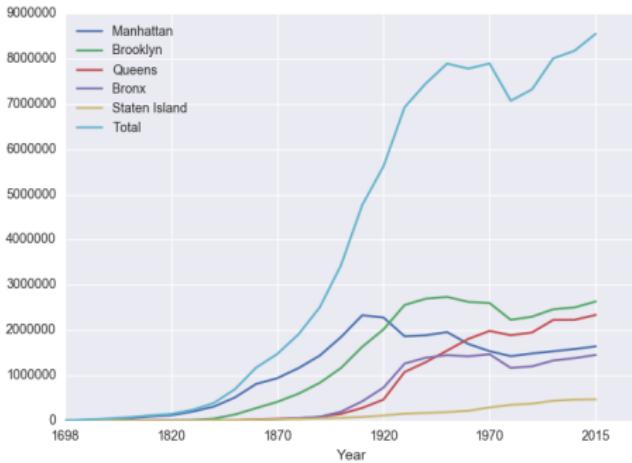
# In Pairs or Triples



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`
- `print("S I:", pop["Staten Island"].std())`
- `pop.plot.bar(x="Year")`

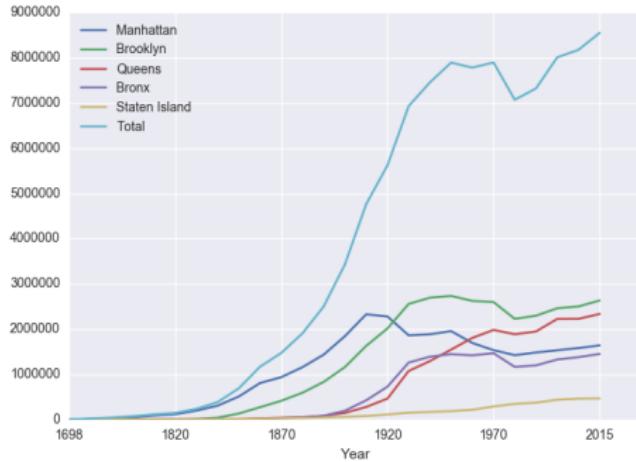
# In Pairs or Triples



Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`
- `print("S I:", pop["Staten Island"].std())`
- `pop.plot.bar(x="Year")`
- `pop.plot.scatter(x="Brooklyn", y= "Total")`

# In Pairs or Triples



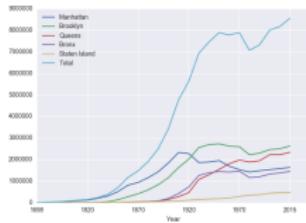
Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`
- `print("S I:", pop["Staten Island"].mean())`
- `print("S I:", pop["Staten Island"].std())`
- `pop.plot.bar(x="Year")`
- `pop.plot.scatter(x="Brooklyn", y= "Total")`
- `pop["Fraction"] = pop["Bronx"]/pop["Total"]`

# Solutions

Predict what the following will do:

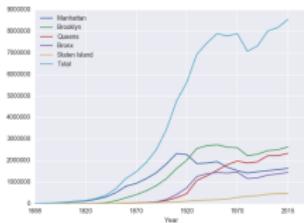
- `print("Queens:", pop["Queens"].min())`



# Solutions

Predict what the following will do:

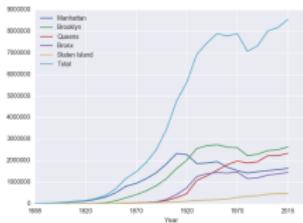
- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*



# Solutions

Predict what the following will do:

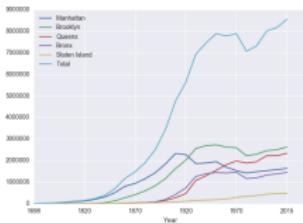
- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`



# Solutions

Predict what the following will do:

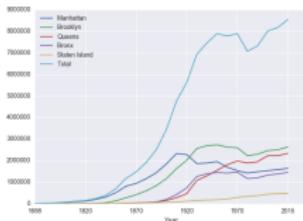
- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*



# Solutions

Predict what the following will do:

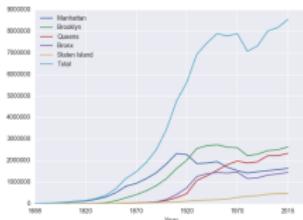
- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*
- `print("S I :", pop["Staten Island"].std())`



# Solutions

Predict what the following will do:

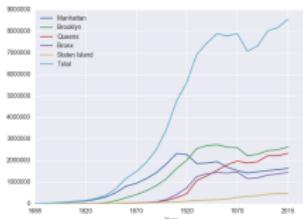
- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*
- `print("S I :", pop["Staten Island"].std())`  
*Standard deviation of values in the column "Staten Island".*



# Solutions

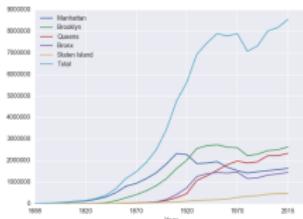
Predict what the following will do:

- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*
- `print("S I :", pop["Staten Island"].std())`  
*Standard deviation of values in the column "Staten Island".*
- `pop.plot.bar(x="Year")`



# Solutions

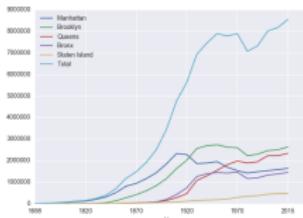
Predict what the following will do:



- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*
- `print("S I :", pop["Staten Island"].std())`  
*Standard deviation of values in the column "Staten Island".*
- `pop.plot.bar(x="Year")`  
*Bar chart with x-axis "Year".*

# Solutions

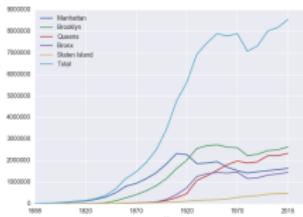
Predict what the following will do:



- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*
- `print("S I :", pop["Staten Island"].std())`  
*Standard deviation of values in the column "Staten Island".*
- `pop.plot.bar(x="Year")`  
*Bar chart with x-axis "Year".*
- `pop.plot.scatter(x="Brooklyn", y= "Total")`

# Solutions

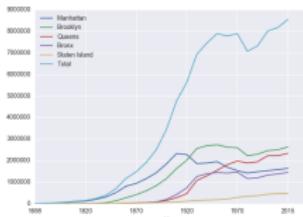
Predict what the following will do:



- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*
- `print("S I :", pop["Staten Island"].std())`  
*Standard deviation of values in the column "Staten Island".*
- `pop.plot.bar(x="Year")`  
*Bar chart with x-axis "Year".*
- `pop.plot.scatter(x="Brooklyn", y= "Total")`  
*Scatter plot of Brooklyn versus Total values.*

# Solutions

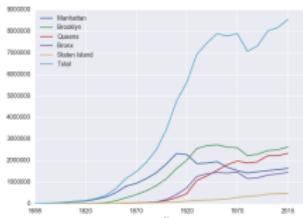
Predict what the following will do:



- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*
- `print("S I :", pop["Staten Island"].std())`  
*Standard deviation of values in the column "Staten Island".*
- `pop.plot.bar(x="Year")`  
*Bar chart with x-axis "Year".*
- `pop.plot.scatter(x="Brooklyn", y= "Total")`  
*Scatter plot of Brooklyn versus Total values.*
- `pop["Fraction"] = pop["Bronx"]/pop["Total"]`

# Solutions

Predict what the following will do:



- `print("Queens:", pop["Queens"].min())`  
*Minimum value in the column with label "Queens".*
- `print("S I:", pop["Staten Island"].mean())`  
*Average of values in the column "Staten Island".*
- `print("S I :", pop["Staten Island"].std())`  
*Standard deviation of values in the column "Staten Island".*
- `pop.plot.bar(x="Year")`  
*Bar chart with x-axis "Year".*
- `pop.plot.scatter(x="Brooklyn", y= "Total")`  
*Scatter plot of Brooklyn versus Total values.*
- `pop["Fraction"] = pop["Bronx"]/pop["Total"]`  
*New column with the fraction of population that lives in the Bronx.*

# In Pairs or Triples

Write a complete Python program that reads in the file, `cunyF2016.csv`, and produces a scatter plot of full-time versus part-time enrollment.

College	Undergraduate		
	Full-time	Part-time	Total
Banach	11,288	3,922	15,210
Brooklyn	10,198	4,208	14,406
City	10,087	3,250	13,317
Hunter	12,223	4,500	16,723
John Jay	9,831	2,843	12,674
Lehman	6,600	4,720	11,320
Medgar Evers	4,760	2,059	6,819
NYCCT	10,912	6,370	17,282
Queens	11,693	4,833	16,526
Staten Island	9,584	2,948	12,532
York	5,066	3,192	8,258

`cunyF2016.csv`

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*Solution:*

- 1 *Include pandas & pyplot libraries.*

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`cunyF2016.csv`

*Solution:*

① *Include pandas & pyplot libraries.*

② *Read in the CSV file.*

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cunyF2016.csv

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- ② *Read in the CSV file.*
- ③ *Set up a scatter plot.*
- ④ *Display plot.*

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Staten Island	9,584	2,948	12,532
York	5,066	3,192	8,258

`cunyF2016.csv`

*Solution:*

- 1 *Include pandas & pyplot libraries.*

```
import matplotlib.pyplot as plt  
import pandas as pd
```

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import matplotlib.pyplot as plt  
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```

- ② *Read in the CSV file.*

```
pop=pd.read_csv('cunyF2016.csv',skiprows=1)
```

- ③ *Set up a scatter plot.*

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`cunyF2016.csv`

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```

- ② *Read in the CSV file.*

```
pop=pd.read_csv('cunyF2016.csv',skiprows=1)
```

- ③ *Set up a scatter plot.*

```
pop.plot(x="Full-time",y="Part-time")
```

- ④ *Display plot.*

# In Pairs or Triples

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`cunyF2016.csv`

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- ② *Read in the CSV file.*

```
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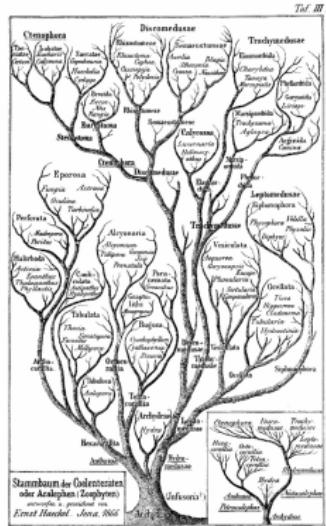
- ③ *Set up a scatter plot.*

```
pop.plot(x="Full-time",y="Part-time")
```

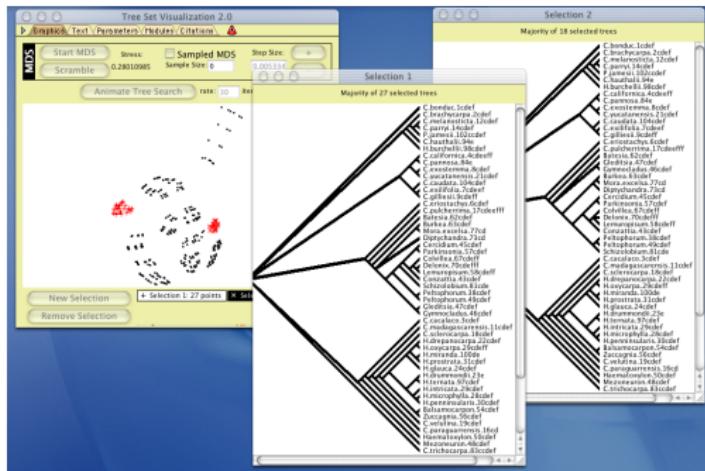
- ④ *Display plot.*

```
plt.show()
```

CS Survey: Prof. St. John, computational biology

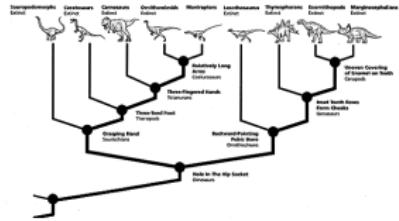


## Haekel's Tree of Life



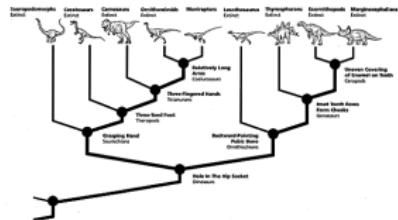
Amenta & Klingner 2002

CS Survey: Prof. St. John, computational biology



(American Museum of Natural History)

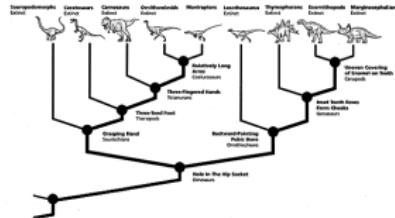
# CS Survey: Prof. St. John, computational biology



(American Museum of Natural History)



CS Survey: Prof. St. John, computational biology

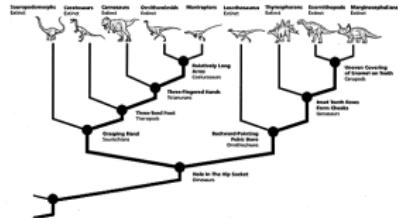


- Finding optimal evolutionary histories for biological data.

(American Museum of Natural History)



CS Survey: Prof. St. John, computational biology

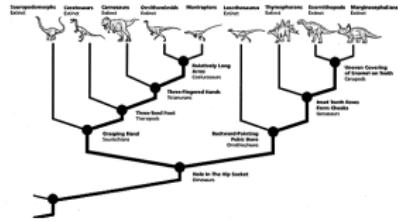


- Finding optimal evolutionary histories for biological data.
  - Computationally hard questions.

(American Museum of Natural History)



CS Survey: Prof. St. John, computational biology

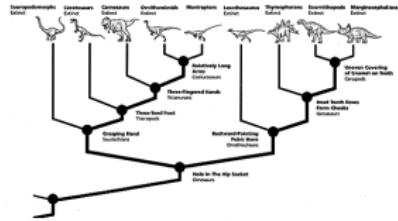


(American Museum of Natural History)

- Finding optimal evolutionary histories for biological data.
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  - Collaborate with biologists & anthropologists at AMNH, & team of undergraduate researchers.



CS Survey: Prof. St. John, computational biology

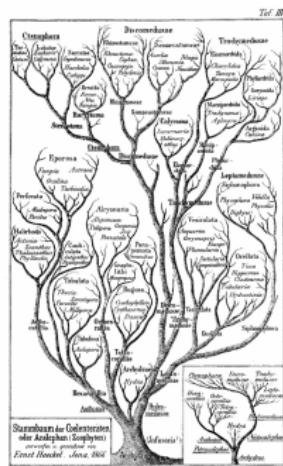


(American Museum of Natural History)

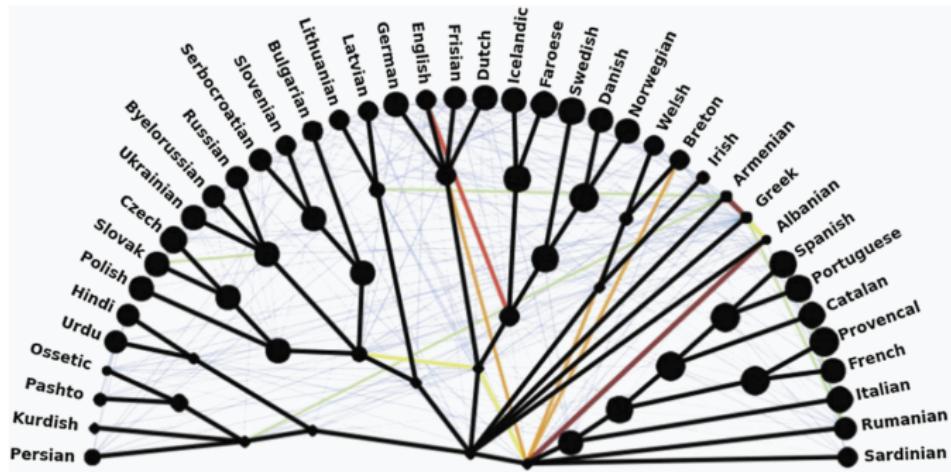
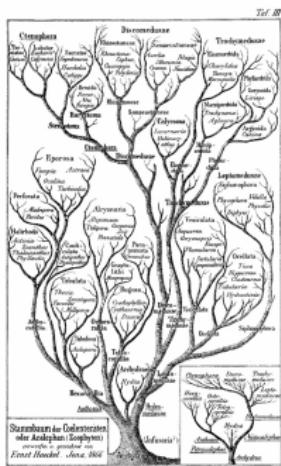


- Finding optimal evolutionary histories for biological data.
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  - Research Experience for Undergraduates: tree-based networks

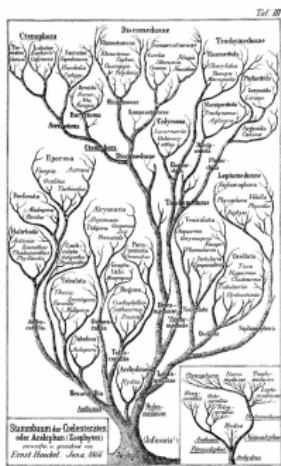
# Lecture Slip: Tree-Based Networks



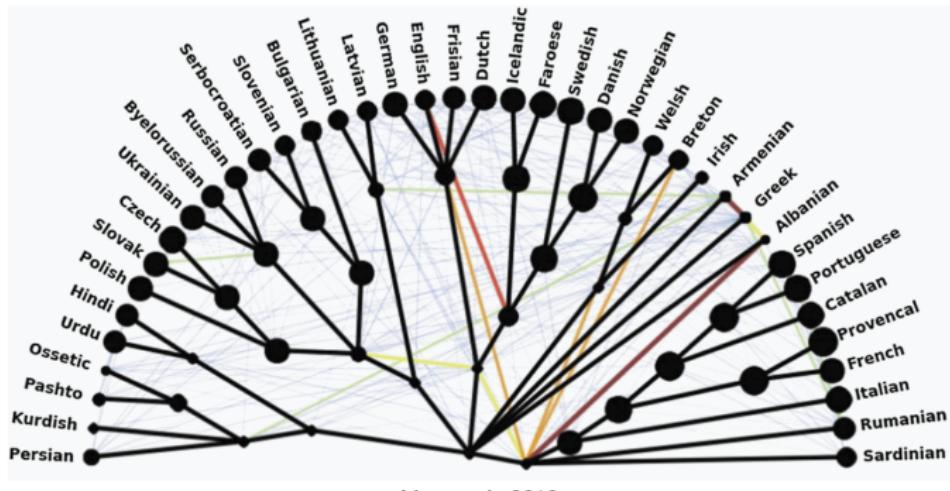
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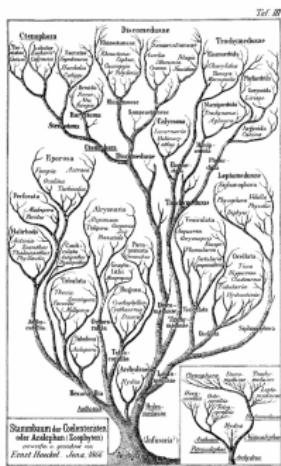


Haekel

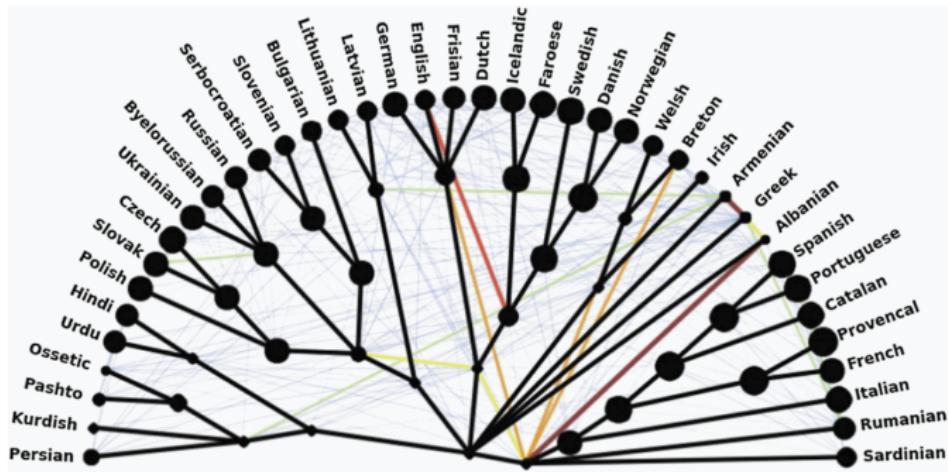


List *et al.*, 2013

# Lecture Slip: Tree-Based Networks



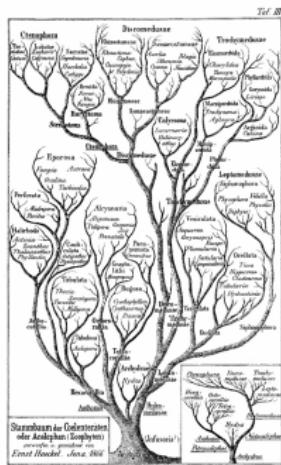
Haekel



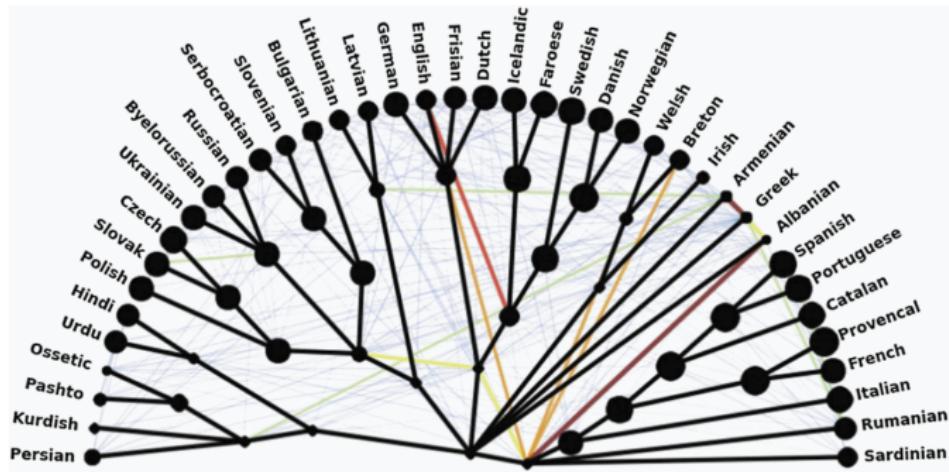
List *et al.*, 2013

- Evolutionary history can be represented by a tree.

# Lecture Slip: Tree-Based Networks



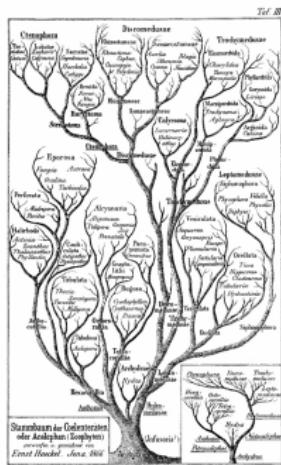
Haeckel



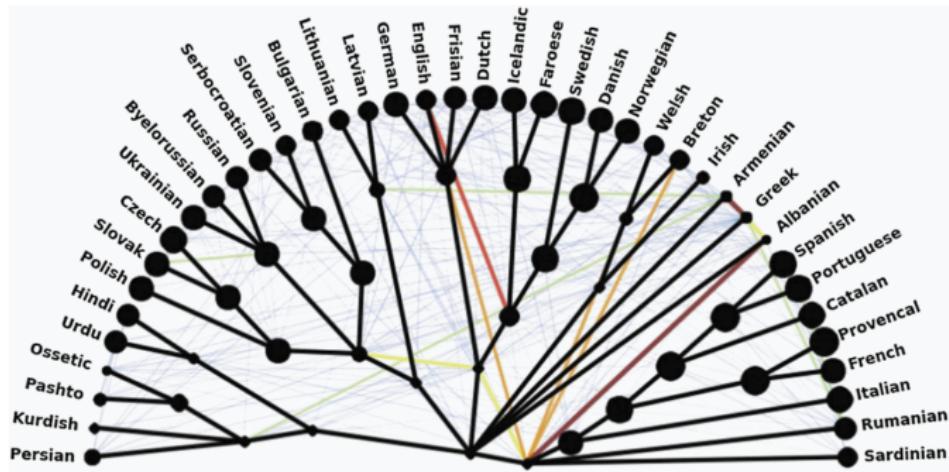
List et al., 2013

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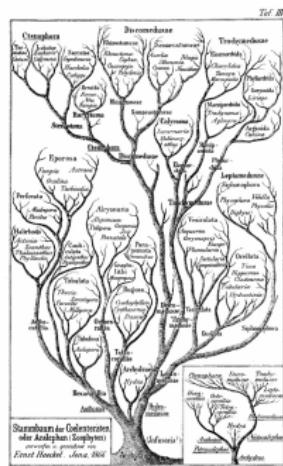
Haeckel



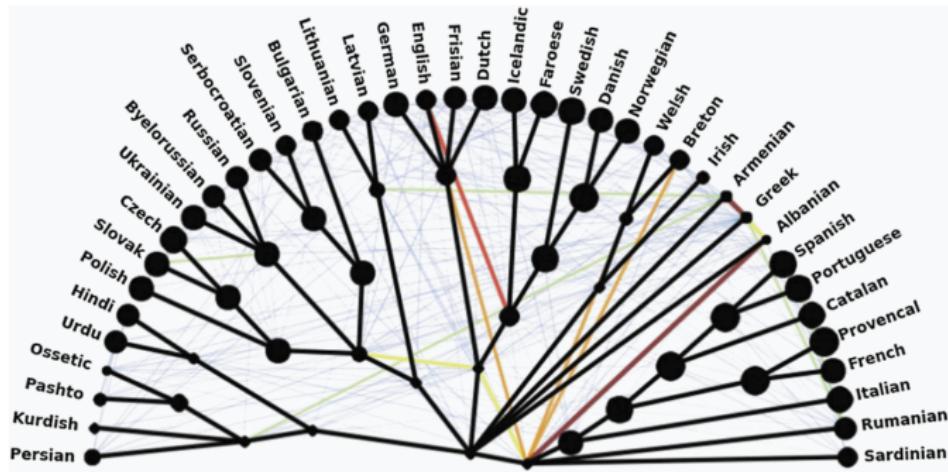
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# Lecture Slip: Tree-Based Networks



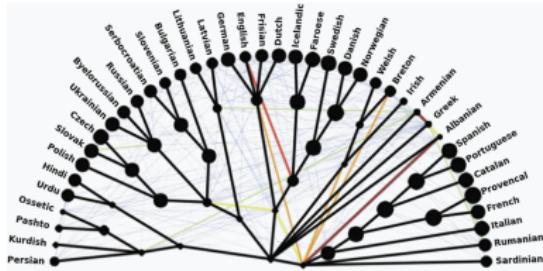
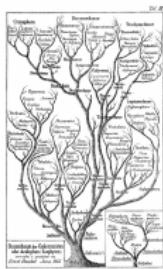
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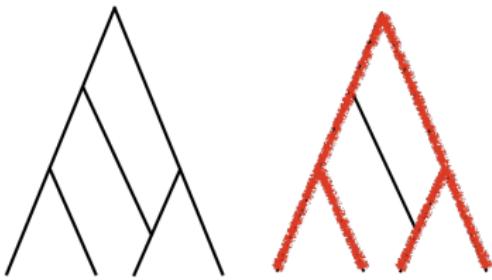
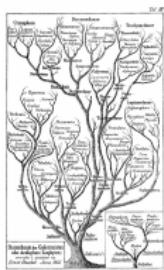
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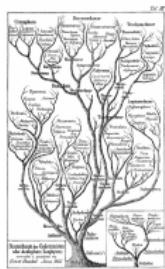
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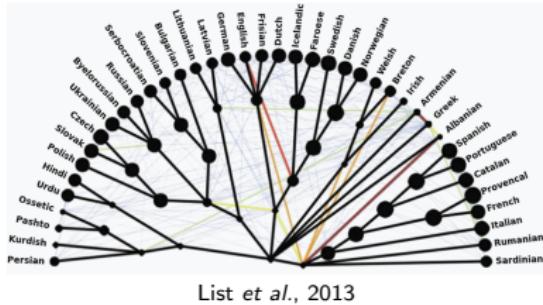
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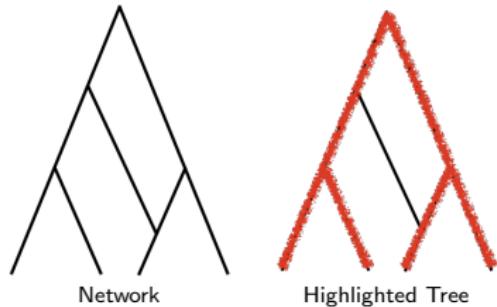
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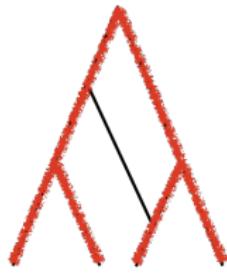
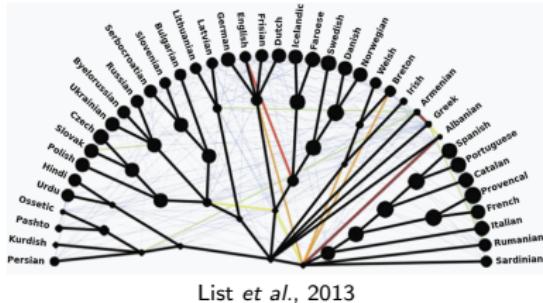
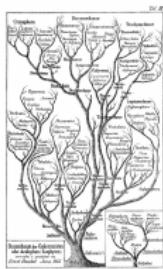
Haekel



List et al., 2013



# Lecture Slip: Tree-Based Networks



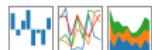
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# Recap

- On lecture slip, write down a topic you wish we had spent more time (and why).

pandas

$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$

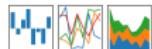


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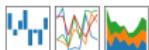
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- ▶ Pandas library has elegant solutions for accessing & analyzing structured data.
- ▶ Can manipulate individual columns or rows ('Series').
- ▶ Has useful functions for the entire sheet ('DataFrame') such as plotting.

# Lecture Slips & Writing Boards



- Turn in lecture slips & writing boards as you leave...