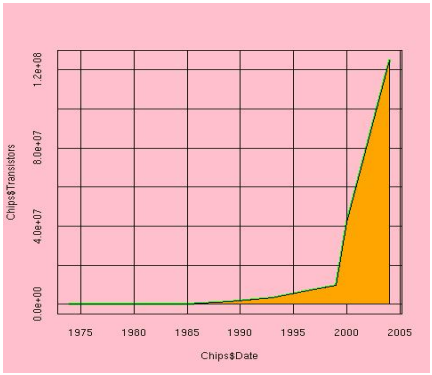
What do you think of this plot?



FIND 5 things that you would change

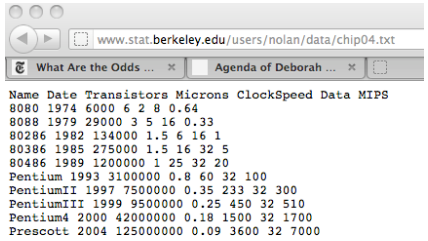
Let's fix it!

Making good plots is an iterative process

Goal is to convey a message as clearly as possible

Visit the website

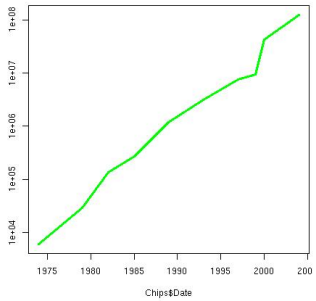
http://www.stat.berkeley.edu/users/nolan/data/chip04.txt



Read it into R

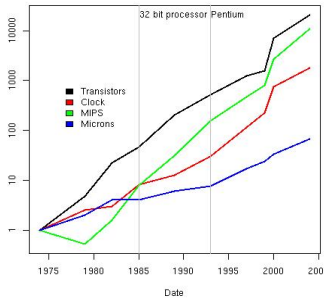
```
> chips = read.table("http://
www.stat.berkeley.edu/users/nolan/data/
chip04.txt", header = TRUE)

> class(chips)
[1] "data.frame"
> names(chips)
[1] "Name"       "Date"       "Transistors"
[4] "Microns"    "ClockSpeed" "Data"
[7] "MIPS"
> dim(chips)
[1] 10  7
```

This is pretty easy to get




```
plot(chips$Date,
chips$Transistors,
type ="l",
lwd = 3,
col ="green",
log ="y")
```

How can we improve it even more?



- Add more data
- Add legend for different information
- Add reference lines for important dates

Review Plotting Functions

- `hist()` histogram
- `boxplot()` boxplot
- `dotchart()` dotchart
- `plot()` for scatter plots, line plots, density plots
- `barchart()`
- `pie()`
- `mosaicplot()`
- `abline()` add line to canvas
- `points()` add points to canvas
- `lines()` add line segments to canvas
- `text()` add text to canvas

Review Plot Arguments

`?plot.default`

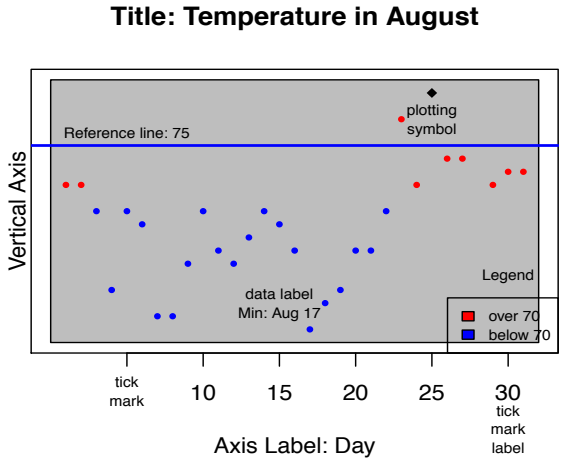
- `type = "l"` "p" for points, "l" for lines, "n" for nothing
- `ylim = c(0, 1)` the range for the scale of the axis
- `xlab = "x axis label"`
- `main = "plot title"`
- `col =` vector of colors
- `log = "y"` use log scale on y axis, can be "x" or "xy"
- `lwd = 2` thickness of line
- `pch = 19` plotting character – check other numbers
- `cex = 0.5` character magnification
- `lty = 2` type of line – check other numbers
- `las = 1` 0,1,2, or 3 style of tick mark labels

Graph Construction

Outline

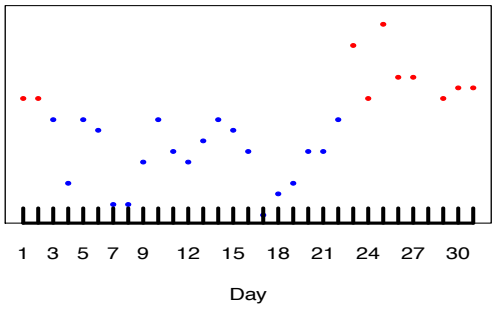
- Vocabulary
- 3 Properties of good graph construction
  - Data stand out
  - Facilitate comparison
  - Information rich
- Perception
- Case studies

Vocabulary

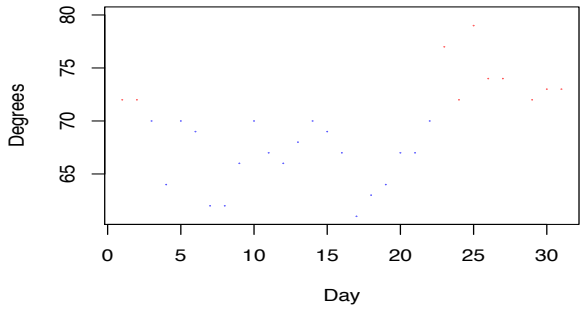


Data Stand Out

Avoid having other graph elements interfere with data

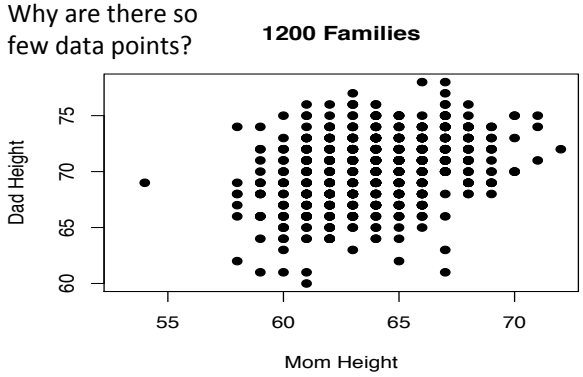


Use visually prominent symbols



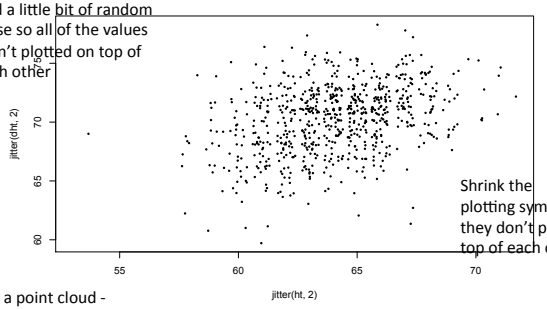
Avoid over-plotting

Why are there so few data points?



One way to avoid over plotting: Jitter the values

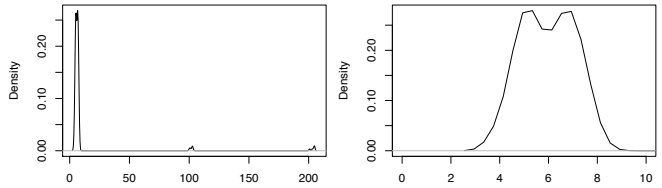
Add a little bit of random noise so all of the values aren't plotted on top of each other



Shrink the plotting symbol so they don't plot on top of each other

See a point cloud -

Different values of data may obscure each other



Most of the data are in the 0 to 10 range.
The few large values obscure the bulk of the data.
Consider mentioning these large values in a caption, instead of showing them in the plot.

Choosing the Scale of the Axis

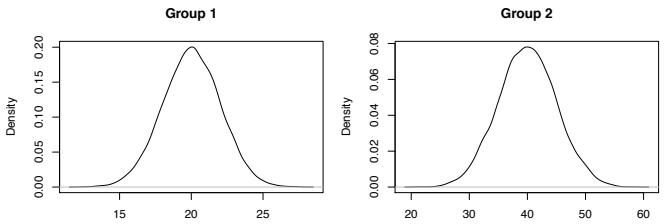
- Include all or nearly all of the data
- Fill data region
- Origin need not be on the scale
- Choose a scale that improves resolution (to be continued)

Eliminate superfluous material

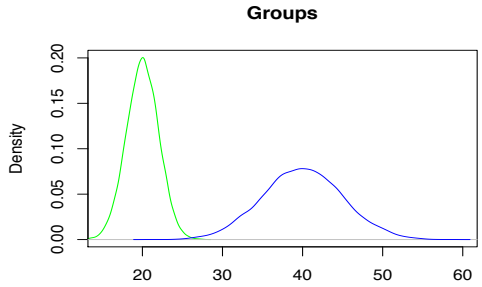
- Chart junk – stuff that adds no meaning, e.g. butterflies on top of barplots, background images
- Extra tick marks and grid lines
- Unnecessary text and arrows
- Decimal places beyond the measurement error or the level of difference

Facilitate Comparisons

Put Juxtaposed plots on same scale



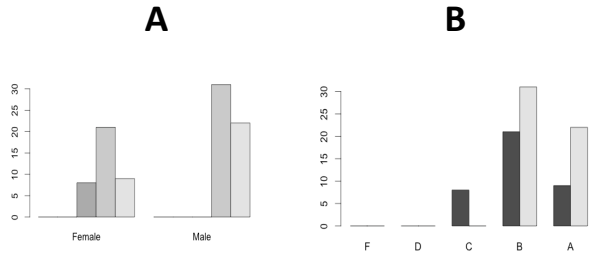
Make it easy to distinguish elements of *superposed* plots (e.g. color)



Choosing the Scale

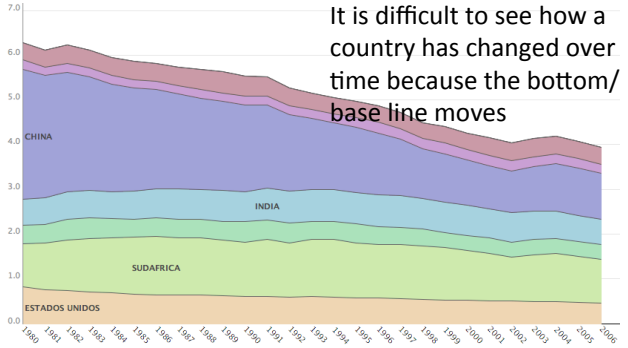
- Keep scales on x and y axes the same for both plots to facilitate the comparison
- Zoom in to focus on the region that contains the bulk of the data
- These two principles may go counter to one another
- Keep the scale the same throughout the plot (i.e., don't change it mid-axis)

Emphasizes the important difference



Which of these side-by-side bar plots emphasizes the important?

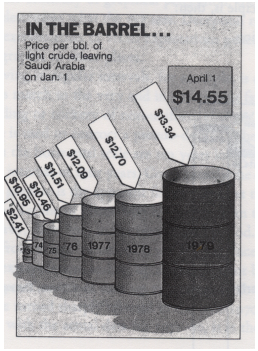
Avoid Jiggling the baseline



It is difficult to see how a country has changed over time because the bottom/ base line moves

Comparison: volume, area, height

We naturally compare the volume of the barrels, but the change is really the height of the barrels



Information Rich

How to make a plot information rich

- Describe what you see in the **Caption**
- Add context with **Reference Markers** (lines and points) including text
- Add **Legends** and **Labels**
- Use color and plotting symbols to add more information
- Plot the same thing more than once in different ways/scales
- Reduce clutter

Captions

- Captions should be comprehensive
- Self-contained
- Captions should:
  - Describe what has been graphed
  - Draw attention to important features
  - Describe conclusions drawn from graph

Good Plot Making Practice

- Put major conclusions in graphical form
- Provide reference information
- Proof read for clarity and consistency
- Graphing is an iterative process
- Multiplicity is OK, i.e., two plots of the same variable may provide different messages
- Make plots data rich

Perception

Color, shape (including banking) can affect your ability to make good comparisons

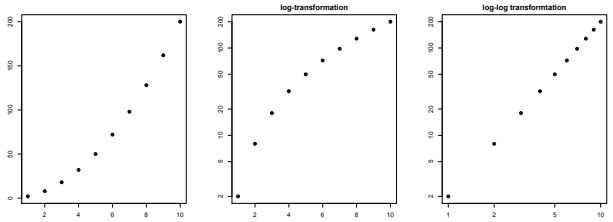
Banking: Aspect Ratio

- The height/width of the data region was selected to be about 1 so that the trend line is at about 45 degrees.
- The Aspect ratio affects our visual decoding of the rate of change
- The banking to 45 degrees helps us see rate of change
- The ability to effectively judge rate of change allows us to see important patterns in data

Banking at 45 degrees

- Roughly: Examine the absolute value of the orientation of segments, they should be centered at 45 degrees.
- Transformations to improve the aspect ratio uncovers the structure of the relationship between variables
- Easier to see important features

Bank to 45 degrees



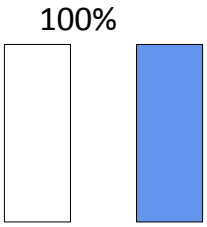
Shapes

POP QUIZ!!!

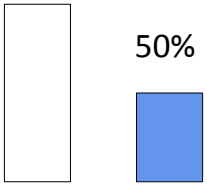
Number your paper 1-6

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

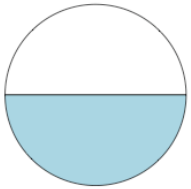
Warm up:
The area of the blue is ___ % of the area of the white



Warm up:
The area of the blue is ___ % of the area of the white

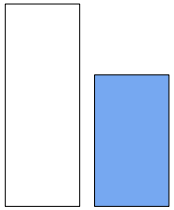


Warm up:
The area of the blue is ___ % of the area of the white

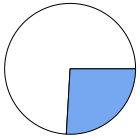


100%

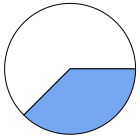
1. The area of the blue is ___ % of the area of the white



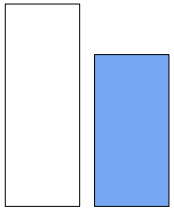
2 The area of the blue is ___ % of the area of the white



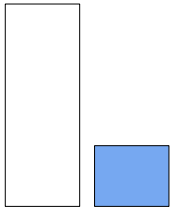
3. The area of the blue is ___ % of the area of the white



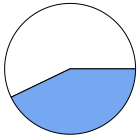
4. The area of the blue is ___ % of the area of the white



5. The area of the blue is ___ % of the area of the white



6 The area of the blue is ___ % of the area of the white



How accurate were you?

You Guess	Truth	Absolute Error	Type
1. __70__	65	5	Bar
2. __33__	35	2	Pie
3. __75__	60	15	Pie
4. __75__	75	0	Bar
5. __35__	30	5	Bar
6. __85__	75	10	Pie

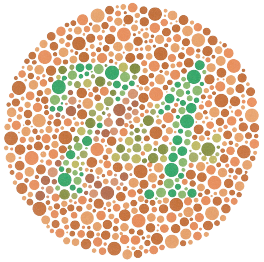
Bar plot vs Pie chart

- Cleveland's experiment had a group of subjects judge 40 pairs of values on bar chars and the same 40 pairs on pie charts: **What percent the smaller was of the larger?**
- Pie chart judgments are less accurate than bar chart judgments
- Bar chart errors are about the same size for all percents.
- Pie chart errors tend to be larger for percents greater than 35%

Color

Color Guidelines

- Choosing a set of colors which work well together is a challenging task for anyone who does not have an intuitive gift for color
- 7-10% of males are red-green color blind.

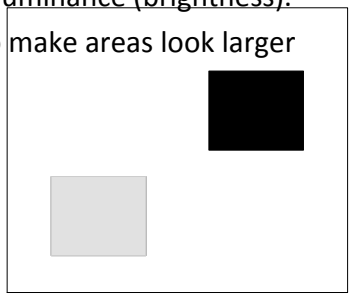


Colorfulness

- Saturated/colorful colors are hard to look at for a long time.
- They tend to produce an after-image effect which can be distracting.

Luminance

- If the size of the areas presented in a graph is important, then the areas should be rendered with colors of similar luminance (brightness).
- Lighter colors tend to make areas look larger than darker colors

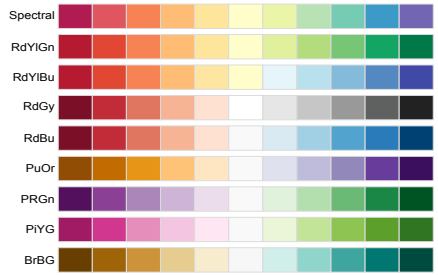


Data Type and Color

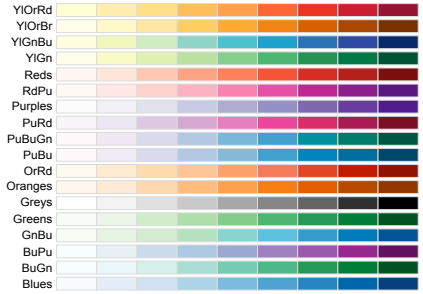
- Qualitative – Choose a **qualitative** scheme that makes it easy to distinguish between categories
- Quantitative – Choose a color scheme that implies magnitude.
  - Does the data progress from low to high? Use a **sequential** scheme where light colors are for low values
  - Do both low and high value deserve equal emphasis? Use a **diverging** scheme where light colors represent middle values

Brewer's Qualitative Palettes

Brewer's Diverging Palettes



Brewer's Sequential Palettes



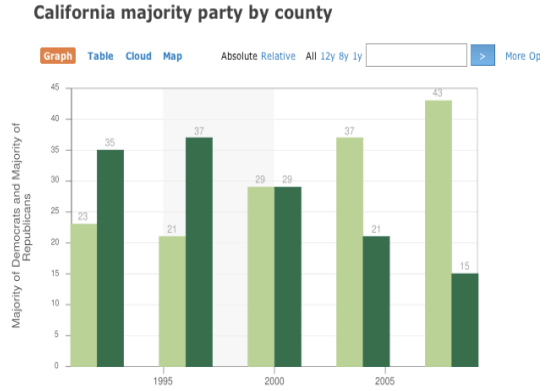
Cases

The Plotting Process

- Determine what's the message
- Help the data speak
- Plotting is an iterative process –
- An artist makes many sketches before painting the masterpiece

Case: Voter Registration Trends in California

How would you improve this plot?



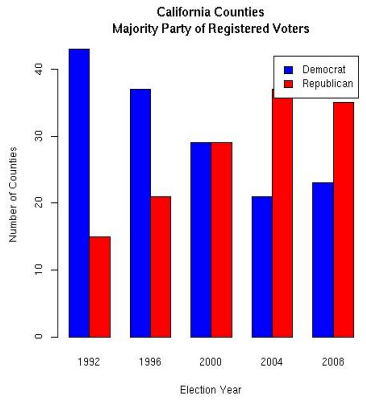
Changes

- Location of tick marks under bars
- Color of bars – indicate party
- Title
- Y-axis label confusing
- X-axis label missing
- Check data for understanding of how plot is made

Data

```
Majority of Democrats, Majority of Republicans, Election Year
21,37,"2004"
23,35,"2008"
29,29,"2000"
37,21,"1996"
43,15,"1992"
```

Sources: California Secretary of State
http://www.sos.ca.gov/elections/ror/60day presprim/hist reg stats.pdf



What's the message?

- How party registration has changed over the past presidential elections
- More informative if we have registration figures for people not counties
- County size may be a lurking variable - small counties tend to be rural and conservative

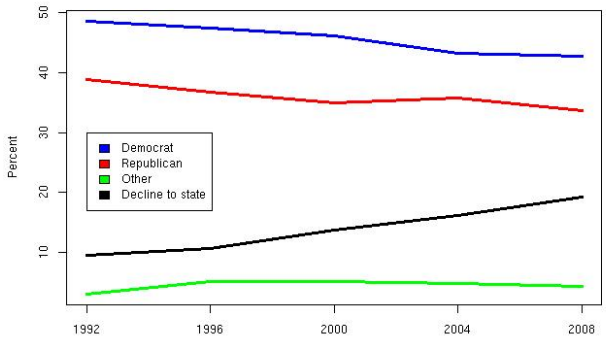
Can we make it more information rich?

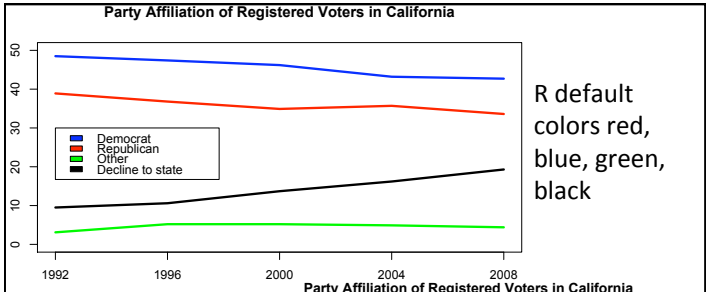
Data

year, eligible, registered, dem, rep, other, decline
1992, 20612814, 13217022,.485, .389, .031, .095
1996, 19298379, 14314658, .474, .368, .052, .106
2000, 21190865, 14676174, .462, .349, .052, .137
2004, 21843202, 14945031, .432, .357, .049, .162
2008, 22987562, 15468551, .427, .336, .044, .193

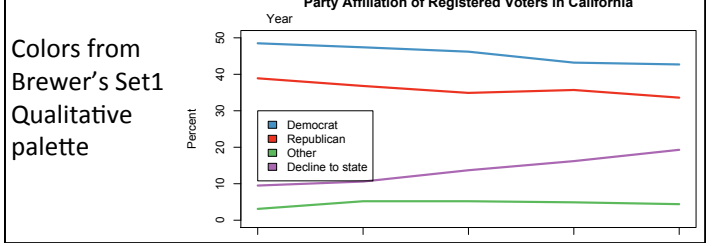
How about a line plot rather than bar chart?

Since Other and "Decline to State" are about 25% of the 2008 registrations, leaving them out of the plot distorts the message.





R default colors red, blue, green, black



Colors from Brewer's Set1 Qualitative palette

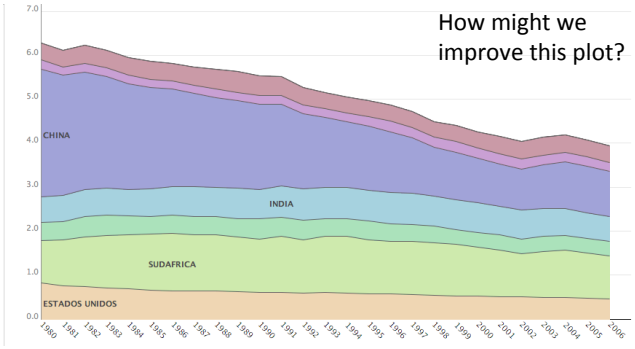
Brief look at how to use the special colors from Brewer's palettes in R

```
> library(RColorBrewer)
> colors = brewer.pal(9, "Set1")

> plot(x, y, type = "l", col = colors[1])
> colors[1]
[1] "#377EB8"
```

- R doesn't give regular English names to these colors. More later on this.

Case: CO2 emissions around the world

ManyEyes and CO_2



Changes

- Superpose rather than stack the curves so the baseline doesn't jiggle
- Use color on the lines rather than filling polygons

Many Eyes CO_2 txt file

Uploaded by: sopecontodo Created at: Nov 30 2010
Data source: Unknown
Description:

View as text

	Kilos de CO2 emitidos por cada dÃ³lar del PIB (PPP, 2005)	1980	1981	1982	1983	1984	1985
1	Argentina	0.38333186	0.381428156	0.406759539	0.398360537	0.394589705	0.403230413
2	Brasil	0.202990595	0.194973813	0.194266889	0.194648263	0.187318277	0.186319816
3	China	2.904045926	2.732955025	2.680960849	2.548963143	2.405590686	2.297552842
4	India	0.582845294	0.591251121	0.607423961	0.614271009	0.611892734	0.637833189
5	Mexico	0.422862904	0.425115073	0.466109144	0.452388983	0.425907729	0.394161616
6	Sudafrica	0.96297576	1.02965463	1.127518054	1.195715963	1.230043609	1.27769729
7	Estados Unidos	0.813798582	0.761893692	0.737590753	0.711116551	0.683594274	0.659206585

watch this add to topic center Visualize rate this

Read into R from the Web

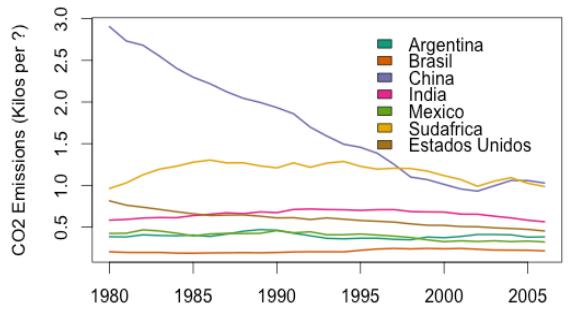
```
myData  = read.table(
url("http://www.stat.berkeley.edu/users/nolan/data/
    CO2Nations.txt"),
            header = TRUE, sep = "\t")
> head(myData)
 "Kilos…."     X1980      X1981      X1982      X1983      X1984    …
Argentina 0.3833319 0.3814282 0.4067595 0.3983605 0.3945897
Brasil      0.2029906 0.1949738 0.1942669 0.1946483 0.1873183
China      2.9040459 2.7329550 2.6809608 2.5489631 2.4055907
India       0.5828453 0.5912511 0.6074240 0.6142710 0.6118927
Mexico     0.4228629 0.4251151 0.4661091 0.4523890 0.4259077
Sudafrica 0.9629758 1.0296546 1.1275181 1.1957160 1.2300436
```

What do you notice about the data?

What do you notice about the data?

- The data frame has a row for every country and a column for every year
- In R, the variables are the columns of the data frame
- The variables are years, e.g., X1980. Note that R put an X in front so that the name starts with a letter.

What can you see now?



Case: CO2 levels at Mauna Loa

Time and the horizontal axis