First Lesson - Births Example

US Births in 2015

Here is some data giving the number of live births in the United States each day of 2015.

```
##         date births wday year month day_of_year day_of_month day_of_week
## 1 2015-01-01   8068  Thu 2015     1           1            1           5
## 2 2015-01-02  10850  Fri 2015     1           2            2           6
## 3 2015-01-03   8328  Sat 2015     1           3            3           7
## 4 2015-01-04   7065  Sun 2015     1           4            4           1
## 5 2015-01-05  11892  Mon 2015     1           5            5           2
## 6 2015-01-06  12425  Tue 2015     1           6            6           3
```

Your Turn

1. Pick out a particular day (perhaps your birthday) and find out if the number of births that day is high, low, or about average.
2. How can you determine what consitutes high, low, or about average?
3. Propose other questions that (a) are interesting, and (b) might be answerable with this data set.

The point of statistics

The purpose of statistics is to help you ...

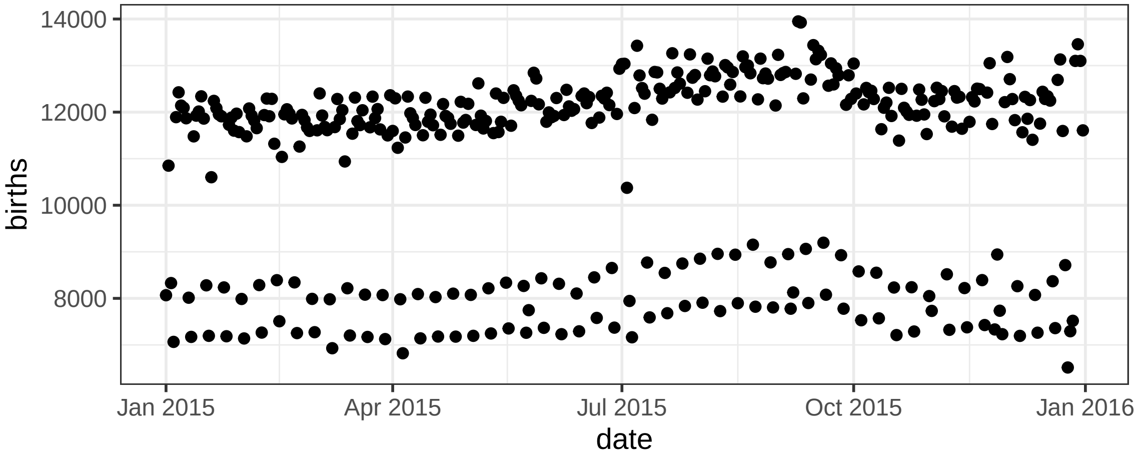
a. Extract useful or interesting *information* from *data*. This also helps to ...
b. Understand the claims that other people are making about patterns in data:
   - Do the claims really reflect the data?
   - Is there enough data to justify the claim?
   - Are there reasonable alternative explanations for the observed patterns?
c. Plan how to acquire new data that will help resolve uncertainty, disputes, or ambiguities.

Our course in statistics will ...

a. Teach you a variety of methods for turning data into a form that people can make sense of.
   - Know which methods are most helpful for which purposes.
   - Identify when a method is *not* working out ... so you can try a different method.
b. Help you learn the common objects and concepts that make up statistics.
   - Graphics to display patterns in data.
   - Numerical descriptions summarizing patterns in data.
   - Tests for whether a pattern is uncertain or might just be due to happenstance.

Graphics can show patterns

```
gf_point(births ~ date, data = Births2015)
```



1. What patterns do you notice in this plot?
2. What possible explanations could there be for these patterns?

How do we make this plot?

We are going to use this plot

- to learn how to create plots using the `ggformula` package
- to begin thinking about designing, describing, and interpreting plots more generally

Two important questions

To get R (or any software) to create this plot (or do anything else, really), there are two important questions you must be able to answer.

Before continuing, think about **what those two questions might be**.

The Questions

To get R (or any software) to create a plot, there are two important questions you must be able to answer:

1. What do you want the computer to do?

Part of learning statistics is learning the various "kinds of what" are appropriate in one setting or another. Learning these objects and their names simplifies answering Question 1. Examples: scatterplot, groupwise means, box-and-whisker plot, regression, etc.

2. What must the computer know in order to do that?

Answering this question also involves knowing the "kinds of what" that the computer can be given to work on. Almost all of the operations in introductory statistics involve two distinct types of "what":

- the dataset: a rectangular, spreadsheet-like array of rows and columns. Ours is called `Births2015`. It has 365 rows and 4 columns.
- the variables: the columns of the data set. `Births2015` has 4 variables named `date`, `births`, `day_of_year`, and `wday`.

Answers to the questions

To make this plot, the answers to our questions are

1. **What do you want the computer to do?**
   - **Ans.** Make a scatter plot (i.e., a **plot** consisting of **points**)

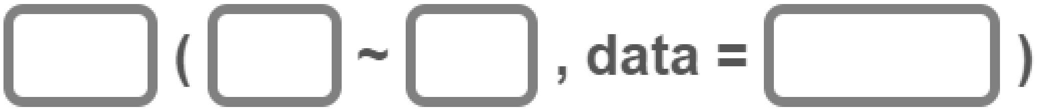
2. **What must the computer know in order to do that?**
   - **Ans. part 1.** The data set to be used in the plot.
   - **Ans. part 2** Roles for the variables, e.g.
     - The variable to be plotted along the y axis.
     - The variable to be plotted along the x axis.

We just need to learn how to tell R these answers.

Plotting with Formulas

The Formula Template

We will provide answers to our two questions by filling in the boxes of this important template:



We just need to identify which portions of our answers go into which boxes.

The Name of the Game

It is useful to provide names for the boxes:

goal (y ~ x , data = mydata , . . .)

These names can help us remember which things go where. (The ... indicates that there are some additional arguments we will add eventually.)

2 Questions and the Formula Template

goal (y ~ x , data = mydata)

Q: What do you want R to do? A: goal

- This determines the function to use.
- For a plot, the function will describe what sorts of marks to draw (points, in our example).
  - other possibilities include lines, boxplots, etc, etc.

Q: What must R know to do that? A: arguments

- This determines the inputs to the function.
- For a plot, we must identify the variables and the data frame that contains them.

Assembling the pieces

Template

goal (y ~ x , data = mydata)

Pieces

box	fill in with	purpose
`goal`	`gf_point`	plot some points
`y`	`births`	y-axis variable
`x`	`date`	x-axis variable
`mydata`	`Births2015`	name of data set

Exercise

Put each piece in its place in the template below and then run the code to create the plot.

```
goal(y ~ x, data = mydata)
```

If you get an "object not found" or "could not find function" error message, that indicates that you have not correctly filled in one of the four boxes from the template.

Note: R is case sensitive, so watch your capitalization.

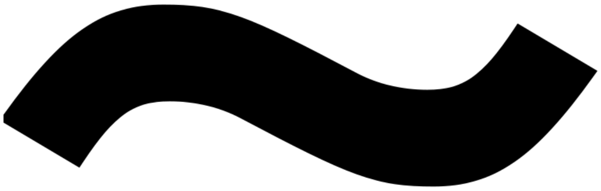
For the record, here are the first few rows of `Births2015`.

```
Births2015 %>% head(3)
```

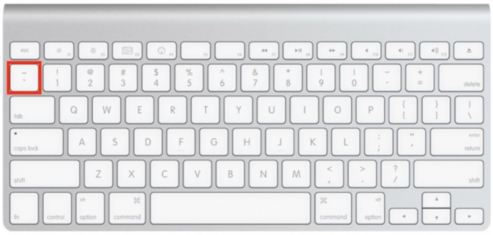
```
##         date births wday year month day_of_year day_of_month day_of_week
## 1 2015-01-01   8068  Thu 2015     1           1            1           5
## 2 2015-01-02  10850  Fri 2015     1           2            2           6
## 3 2015-01-03   8328  Sat 2015     1           3            3           7
```

Formulas

The most distinctive feature of `ggformula` plots is the use of formulas to describe the positional information of a plot. Formulas in R always involve the tilde character, which is easy to overlook. It looks like this:



The position of ~ on the keyboard varies from brand to brand. On Apple keyboards, it's here.



Exercise

Find the ~ on your keyboard.

Using formulas to describe plots

Most gf_ functions take a formula that describes the positional attributes of the plot. Using one of these functions with no arguments will show you the "shape" of the formula it requires.

Exercise

Run gf_point() to see the formula shape.

```r
gf_point()
```

```
## gf_point() uses
##     * a formula with shape y ~ x.
##     * geom:  point
##     * key attributes:  alpha, color, size, shape, fill, group, stroke
##
## For more information, try ?gf_point
```

You should see that gf_point()'s formula has the shape y ~ x, so the y-variable name goes before the tilde and the x-variable name goes after. (Think: "y depends on x". Also note that the y-axis label appears farther left than the x-axis label.)

Exercise

Change date to day_of_year and see how the plot changes. (If you do this on a separate line, you will see both plots at once.)

```
gf_point(births ~ date, data = Births2015)
```

Bonus Exercise (Optional)

Reverse the roles of the variables – changing `births ~ date` to `date ~ births` – to see how the plot changes.

Changing things up – different types of plots

Our plots have points because we have used `gf_point()`. But there are many other `gf_` functions that create different types of plots.

Exercise

Experiment with some other plot types by changing `gf_point()` to one of the following:

- `gf_line()`: connect the dots
- `gf_lm()`: a regression line (lm = linear model)
- `gf_smooth()`: smoothed version of `gf_line()`

Which type of plot reveals **exceptional cases** the best? What are those exceptional cases?

```
gf_point(births ~ date, data = Births2015)
```

Setting and Mapping attributes

The births data in 2015 contains two clear "waves" of dots. One conjecture is that these are weekdays and weekends. We can test this conjecture by putting different days in different colors.

In the lingo of `ggformula`, we need to **map** color to the variable `wday`. **Mapping** and **setting** attributes are different in an important way.

- `color = "navy"` **sets** the color to "navy". All the dots will be navy.
- `color = ~ wday` **maps** color to `wday`. This means that the color will depend on the values of `wday`. A legend (aka, a guide) will be automatically included to show us which days are which.

Exercise

1. Change the color argument so that it maps to `wday`. Don't forget the tilde (`~`).
2. Try some other plot types: `gf_line()`, `gf_smooth()`, etc. Which do you like best? Why?

```
gf________(births ~ date, data = Births2015, color = "navy")
```

Across the decades

Data on births are available for other years as well. (This tutorial has data from 1969 - 1988 and for 2015).

Your Turn

Compare 1978 to 2015. In what ways are the yearly and daily patterns different?

Some suggestions:

- You can put more than one layer of graphics on the same plot by connecting the graphics commands with "pipes": `%>%`
- Use `day_of_year` as the explanatory variable rather than `date`. With `date`, the 1978 and 2015 data will be plotted almost 40 years apart!
- Use color to distinguish the years.

Bonus questions

1. How else could you distinguish the years? (Describe the plot, even if you don't know how to get the plot made.)
2. What would happen if we used `wday` as the explanatory variable rather than `day_of_year`?
3. Which of `gf_point()`, `gf_line()`, `gf_smooth()`, and `gf_lm()` do you like best for these plots? Why?