# Learning R Markdown and Notebooks in RStudio

*May 16, 2018*

## Contents

# Introduction

Today we are going to be talking about creating R Markdown Notebooks and other R Markdown documents via RStudio. The work we are doing today can be done outside RStudio via R packages **rmarkdown** and **knitr** along with the **Pandoc** software package. RStudio has bundled these in a way that makes creating these documents very easy.

R Markdown documents allow the integration of plain text, code, and output. This makes writing reports, sharing reproducible analysis code with collaborators (including one of your main collaborators, *future you*), or simply including narrative to explain the steps in our analysis straightforward. R Markdown Notebooks are a specific type of R Markdown document that allows for literate programming, where you are directly interacting with R while producing a high-quality, reproducible HTML document as output.

In this workshop we will be coding interactively. This is because inherent in what we are doing today is not only writing the code, but seeing what the output looks like. I think that doing this work on the fly together rather than having the code already written will help understand that.

## Install LaTeX distribution via tinytex

Later today we will be making PDF output documents, which means we need a LaTeX distribution. We can install one (even without administrative privileges) using package **tinytex**. Read about this package here.

We start by installing package **tinytex** in R. This can be done by going to Packages pane in RStudio, clicking on the *Install* button and typing in the name of the package. Alternatively we could run `install.packages("tinytex")` in the Console.

Once the package is installed we can use it to install the TinyTeX distribution via the `install_tinytex()` function. This will take a few minutes and we'll have to click OK to three messages and ignore the error message at the end if we are on a Windows machine.

```
tinytex::install_tinytex()
```

When this is done, we'll close RStudio before reopening and checking if things worked using `is_tinytex` and hoping to see `TRUE`. We do.

```
tinytex:::is_tinytex()
```

```
[1] TRUE
```

Last, we add a package to TinyTeX that we'll be using later today to save from having to do it later.

```
tinytex::tlmgr_install("ulem")
```

## Create a new R Notebook

We will be talking about R Markdown documents in general as well as R Notebooks specifically. They are related; a Notebook is a special case of R Markdown that acts in a particular way. We will start with R Notebooks, as I think these encompass a niche that may be particularly useful for graduate students and others who are relatively new to R and analyses.

To easily create a new Notebook in RStudio, go to

> File > New File > R Notebook

You will get an Untitled document. RStudio has some example text and code already in the document along with some basic information to get you started.

### The parts of an R Markdown document

In this new file you've opened, you can see the three basic parts of a R Markdown document. We will talk about each of these briefly now and then go through each section in greater detail.

#### YAML header

At the top, surrounded by sets of three dashes (`---`), is the YAML header. The YAML header is used to define the structure of the document. We will be covering the syntax needed for YAML.

The default YAML header for an R Notebook looks like:

```
---
title: "R Notebook"
output: html_notebook
---
```

#### Text

Next in the document you see sentences of text. This text is written in plain text, and formatting can be controlled the R version of Markdown syntax. We are able to do this via the **rmarkdown** package, which RStudio usually installs and uses automatically (here in lab we may need to install it).

#### Chunks

The last part of an R Markdown document is what's called a *chunk*. The chunk is where the R (or other language) code is inserted into the document. A chunk always begins with three backticks (```` ``` ````) followed by curly braces where we define the language the code chunk will be in. The chunk ends with another set of three backticks. The backtick on many keyboards is found on the same key as the tilde.

The basic code chunk in the initial Untitled R Notebook document looks like this:

~~~~
```{r}
plot(cars)
```
~~~~

We will talk more extensively about YAML headers, writing text via the R Markdown language, and code chunks in a few minutes.

## Previewing an R Notebook

As mentioned in the introduction, R Notebooks were created as a method of literate programming. They allow the integration of plain text, code, and output so you can, e.g, view your analysis code and output while keeping track of your thought process. Unlike other R Markdown documents, R Notebooks are interactive. This means you run code and add output interactively within the document as you work rather than writing the whole document and R code and then compiling the document with output as a final step. This makes R Notebooks more like keeping a scientific notebook and less like writing a report or tutorial, although Notebooks can certainly be used for these latter tasks, as well.

In R Notebooks, we *preview* the document to create the output HTML document. Let's see what that looks like by clicking the *Preview* button at the top of Untitled R Notebook.

### Saving the R Notebook document

As soon as you click the *Preview* button you will be asked to save the document. R Markdown documents must be saved before you can view any output from them. Save this document as `notebook_test.Rmd` into a directory you have access to. This is the same folder you should have saved the PNG file and dataset I sent you, with the dataset inside a folder called `Data`.

We save our R Markdown file as an `Rmd` document, which is the file type for an R Markdown document.

Note that I have purposely not set my working directory. This will allow me to show you additional default features of R Notebooks later in the workshop.

Once we save the document the output document is created and opens in a new window. If it doesn't open, click the *Preview* button again to see the output document. This document is in the same directory and has the same name as our `Rmd` file but is an `nb.html` file. This is the ending given to these HTML R Notebooks.

By default the output document opens in a new window instead of the RStudio Viewer pane. You can change this to open in the Viewer pane via

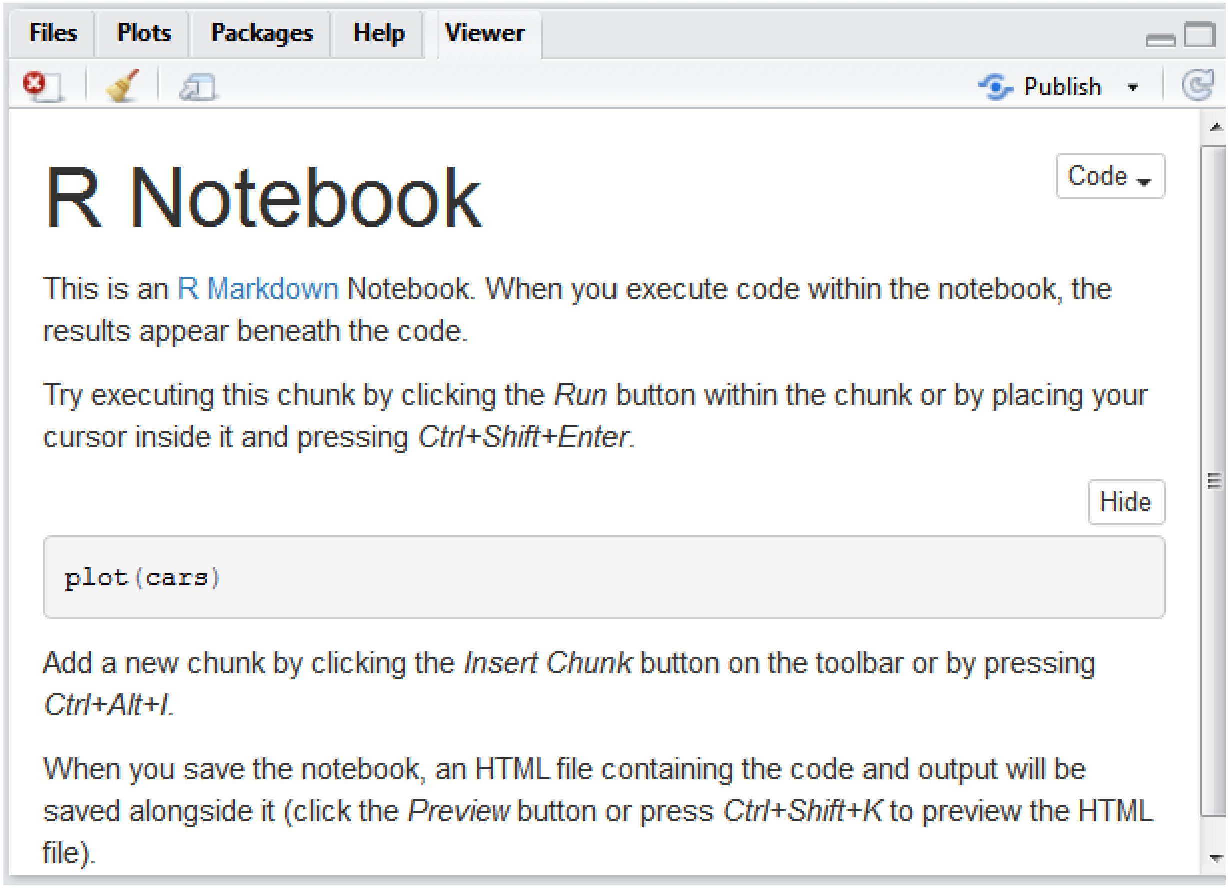
> Tools > Global Options… > R Markdown

and choosing *Viewer Pane* from the `Show output preview in:` drop down menu.

On small monitor computers, opening in a new window may work better than trying to see how things look in the Viewer pane.

## The output document of an R Notebook

Let's take a closer look at the output document, which is a specific type of HTML document ending in `nb.html`, shown below.



R Notebook

This is an R Markdown Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Ctrl+Shift+Enter*.

```
plot(cars)
```

Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Ctrl+Alt+I*.

When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Ctrl+Shift+K* to preview the HTML file).

We see an overall title, which was made in the YAML header of our `Rmd` document. The text shows up in paragraph form, with different types of text (like italic text) and hyperlinks seamlessly included. The R code included in the chunk is now in a gray box, separated from the rest of the text.

In R Notebooks, we have some additional features. We have a *Code* drop-down menu, giving us the options.

Show All Code
Hide All Code
Download Rmd

By default all code we've chosen to include in the document is shown. Choosing *Hide All Code* hides all code for the entire document. We won't talk about the *Download Rmd* option today, but this allows a collaborator to extract the `Rmd` file from the HTML document.

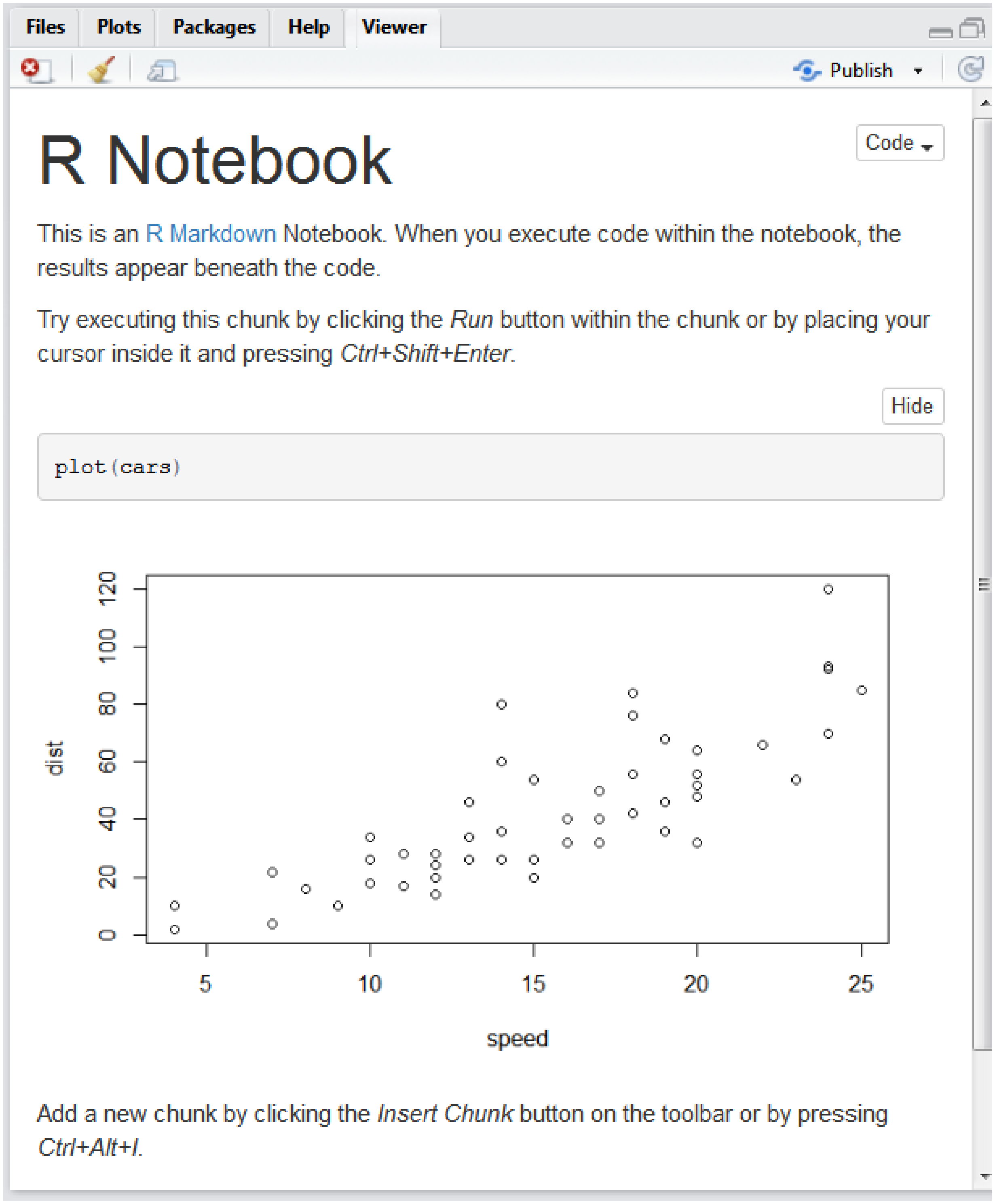
There is also a *Hide* button in the `.nb.html` document. This will be available for each chunk, allowing code to be hidden one chunk at a time. After hiding, this button turns into a *Code* button, allowing us to show the code chunk once again.

## Code output appears only after running code

In our initial output document, we see the code but no code output. In R Notebooks, you have to run the code chunk within the `Rmd` document before it will be included in the output. This interactivity is a big difference between Notebooks and other R Markdown documents.

Our initial document actually tells us how to run the code chunk: we either click the *Run* button within the chunk or put the cursor inside the chunk and press *Ctrl+Shift+Enter* (OS X: *Cmd+Shift+Enter*). Let's do that now.

The code output immediately shows up below the code chunk in our `Rmd` document. This is now the default in RStudio for all Markdown documents (go to *Global Options...* to change this), but it is an inherent part of the nature of R Notebooks coming into play; we write code and run it and have the output show up in our document interactively. Once we have run the chunk we either save the `Rmd` or preview it to see it in the output document.



# R Notebook

This is an R Markdown Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Ctrl+Shift+Enter*.

```
plot(cars)
```

Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Ctrl+Alt+I*.

## Formatting plain text using Markdown

Now that we have seen the basics, I want to talk about each part of an R Markdown document in more detail. I'm going to start with showing how to control the plain text format via Markdown. Markdown is a simple formatting syntax. It has relatively few options, which can be both good and bad.

I often can't remember all of the syntax and have to go back and check how something works. The RStudio cheatsheet is a good resource, as is RStudio's Markdown Basics page.

Let's practice Markdown by adding some plain text to `notebook_doc.Rmd`.

## Headers

Headers in Markdown are indicated using the pound sign, `#`. We make headers of different sizes using different number of `#`. These headers allow us to make a table of contents, so they are nice to include in an R Markdown document.

Add a header to indicate an *Introduction to Markdown* section. This will be a top-level header, so will have a single `#`.

```
# Introduction to Markdown
```

Our secondary header could be titled `## Headers`, with some text about headers beneath it. You will see these changes in the `nb.html` document when you save or push *Preview* again.

The text size of headers is set in the built-in documents in RStudio. In HTML documents they are large, as HTML documents are meant for reading on the computer You'll see headers in other formats, such as PDF documents, are generally smaller. You can change header size of HTML documents, but you'd have to do it via CSS as shown in this Stack Overflow answer, which we won't cover today.

## Emphasis with italics or bold text

We can use italics by wrapping text in single asterisks (`*`): `*italic*`.

Bold text is achieved with double asterisks (`**`): `**bold**`.

The initial text of our R Notebook has examples of italics. Add in a sentence with some bold text in it to see what it looks like in the output document.

## Bulleted and numbered lists

### Bulleted lists

Making bulleted lists involves using a single asterisk (`*`), a plus signs (`+`), or a dash (`-`) at the start of each line, followed by a space and then the list item. If you don't have the space between the symbol and list item you won't get bullets. We indent with $\geq 4$ spaces to get nested bullets.

Let's try it in our practice Notebook.

```
* First bullet
* Second bullet
    + Secondary bullet
```

The output will look like:

- First bullet
- Second bullet
    - Secondary bullet

### Numbered lists

Making a numbered list is similar. We simply use numbers followed by a period and a space before each list item We can use `+` or `*` or letters/numbers to add bullets in a nested list. We'll use letters today for the nested list. Again, we have to indent with $\geq 4$ spaces for the nested elements of the list to work properly.

```
1. Item 1
2. Item 2
3. Item 3
    a. Item 3a
    b. Item 3b
```

1. Item 1

2. Item 2
3. Item 3

    a. Item 3a
    b. Item 3b

You will notice that we need to make a new paragraph for this formatting to work. If we don't, the text is viewed as plain text that is part of the previous paragraph.

Try only using a single line break at the end of the previous paragraph or sentence instead of two and see how you get plain text instead of a list.

## Blockquotes

We use the greater than symbol, `>`, for blockquotes. As long as you don't include two line breaks or spaces at the end of a line, the text will wrap into a single blockquote.

```
> Here is how to write a block quote
as a single block of text even if it is written
on multiple lines
```

> Here is how to write a block quote on a single line even if it is written on multiple lines

To do multiple block quotes in a row (vs a paragraph in a blockquote), end each line with two or more spaces. If you don't put the spaces at the end, the lines will run together on a single line.

```
> Here is the first block quote
> Here is the second
```

> Here is the first block quote
> Here is the second

You can also put line breaks between the lines, but there will then be a line break between each blockquote.

```
> Here is the first block quote

> Here is the second
```

> Here is the first block quote

> Here is the second

## Links

Clickable links can be included by writing a URL in the text.

```
http://rmarkdown.rstudio.com
```

http://rmarkdown.rstudio.com

Alternatively, use brackets and parentheses to hide the address and allow the user to click on a word or phrase. This option was included in the built-in text of our Notebook. The term `R Markdown` is the clickable link.

```
[R Markdown](http://rmarkdown.rstudio.com)
```

R Markdown

## Images

We can add images in Markdown. We'll need a path to the image, so we'll either have the image saved to a folder we have access to or have a web address where the image is stored (for HTML output only).

Including images involves brackets and parentheses much like including links, but the brackets are preceded by a exclamation point (`!`).

In a presentation that's powered by RStudio, we could include their logo by downloading an image of the logo from their website. Let's save the image at https://www.rstudio.com/wp-content/uploads/2014/07/RStudio-Logo-Blue-Gradient.png into the folder we're working in. While we can read it from the URL when making an HTML document, it won't work if we switch to a PDF document output so saving the image locally is the "safest" method.

```
![Caption](RStudio-Logo-Blue-Gradient.png)
```

We will get a caption by default. The caption is what you write within the square brackets. We can remove the caption by making changes to the YAML header, which we'll see soon. I have removed captions from this document, so the RStudio logo I included below has no caption.

Jump to the [Images in a PDF document] section below for an alternative for inserting images that works well for all output document types.

## Inline R code

R code can be evaluated inline using single backticks, `` ` ``, around a lower case `r` along with code. The `r` indicates the language used in the code.

This can be useful if we want to pull something from some results we've made in R and put it within our text. Being able to code it like this means we don't have to copy/paste it in.

Here's an example of what we would write in plain text, using backticks around a lowercase `r` followed by the R code to evaluate.

```
There were `r nrow(mtcars)` rows in the dataset.
```

And this is what the result would look like in the output document.

There were 32 rows in the dataset.

Generally, inline R code should be relatively simple as it will be evaluated every time the document is saved. Code that takes a long time to run should likely be put in a code chunk.

## Plain code blocks

If we are trying to include an example of syntax that we don't want evaluated, we can wrap it in triple backticks much like a code chunk. Unlike code chunks, plain code blocks have no curly braces that indicate the language of the code.

Here's what code would look like if we were showing someone how to use asterisks for italic text.

~~~~
```
Write in *italics* with single asterisks.
```
~~~~

Below is what it would look like in the output document.

```
Write in *italics* with single asterisks.
```

## Including equations in text

Equations or Greek letters can be included within text using LaTeX equations wrapped in dollar signs. We will not go into details on LaTeX equations, but see here for a list of LaTeX mathematical symbols.

### Inline equations

You can include equations within a sentence using single dollar signs. Symbols are preceded by a backslash, `\`.

```
Let's talk about $\sigma^2$ within a sentence, using the Greek letter.
```

Let's talk about $\sigma^2$ within a sentence, using the Greek letter.

### Display equation

To display an equation on its own line, use double dollar signs.

```
Here is how we sum everything together: $$\sum_{i=1}^n X_i$$
```

Here is how we sum everything together:

$$\sum_{i=1}^n X_i$$

## Line breaks

Force new pages by putting three or more dashes or asterisks on a line.

```
****

----
```

## Miscellaneous

You can use superscripts, subscripts, and strikethroughs in Markdown syntax, as well.

#### Superscripts

Superscripts can be indicated with carets, `^`, around the symbol we want in superscript.

```
y^2^
```

$y^2$

#### Subscripts

Subscripts can be indicated with single tildes, `~`, around the subscripted symbol.

```
H~2~O
```

$H_2O$

#### Strikethroughs

Strikethroughs are indicated with double tildes, `~~`, around the terms we want to strike out.

```
~~Strike this out~~
```

~~Strike this out~~

### Going beyond Markdown basics

Markdown syntax, as you can see, is pretty simple. This means you are limited in how much formatting you can do in Markdown. If you want or need to do more complicated things in your Markdown document than what is listed above, you are able to do so. However, that usually will mean writing some code in an alternative syntax such as CSS or LaTeX (depending on the format of the output document). When I am in this situation, I end up searching online and can usually find what I'm looking for and add it to the document.

## YAML header

We will next talk about things we can add or change in the YAML header to change the structure of the document.

By default, RStudio fills in the `output` type based on the kind of document we chose to open. Because we are working with an R Notebook, you can see that the output is an *html_notebook*. RStudio also includes an overall `title` in the YAML header, which we may or may not want.

There are many things we can add or change in the YAML header. Many of these options are outlined at the RStudio HTML R Markdown page. The link above is specific to HTML documents; for PDF documents see the PDF R Markdown page. Controlling the appearance of the different output document types can take different commands.

### Adding title/date/author information to the document

Some of the basic things we can add to the document are titles, authors, and dates. We could also remove the `title` all together by deleting that line.

The title is included by default by RStudio. Let's change it to "Practice Notebook". Let's add the date while we're at it. The date option is `date:`. Each option in the YAML header has a colon after it followed by a space.

```
---
title: "Practice Notebook"
date: May 16, 2018
output: html_notebook
---
```

We can add author information, as well.

```
---
title: "Practice Notebook"
date: May 16, 2018
author: Ariel Muldoon
output: html_notebook
---
```

## Changing the format of the document

Many of the changes we make to the document are done as options to `html_notebook`.

If we look at the help page for `html_notebook`, which we can do via `?html_notebook`, we see some of the options we can control in our output document.

```
html_notebook(toc = FALSE, toc_depth = 3, toc_float = FALSE,
  number_sections = FALSE, fig_width = 7, fig_height = 5,
  fig_retina = 2, fig_caption = TRUE, code_folding = "show",
  smart = TRUE, theme = "default", highlight = "textmate",
  mathjax = "default", extra_dependencies = NULL, css = NULL,
  includes = NULL, md_extensions = NULL, pandoc_args = NULL,
  output_source = NULL, self_contained = TRUE, ...)
```

You can see there are many things you can control, from deciding whether you want to produce typographically correct output automatically using `smart` (which defaults to `TRUE`) to controlling whether or not you get figure captions via `fig_caption` (which also defaults to `TRUE`) and beyond.

We'll hit on only a few of these so you can see what the code looks like. After each change we make, we'll save or preview the document to see how things have changed.

### Adding a table of contents

We can add a table of contents using the `toc` option. As you can see on the help page, it defaults to `FALSE`. To get an automatic table of contents based on the headers we've made we change this to `TRUE`.

We use a new format for the YAML header once we are changing options away from the defaults. This format is important; things won't work how you want if you don't use the correct formatting.

To get the correct formatting, we add a line break after `output:` and indent two spaces before `html_document:`. We add the colon after `html_document`. We then do another line break and indent another two spaces for including `html_document` options that we can see from the help page listed above. In this case we will add `toc: TRUE`.

Below is what that will look like. Again, the formatting is important. If you don't indent before an option within `html_document` it will not take effect.

```
---
title: "Practice Notebook"
date: May 16, 2018
author: Ariel Muldoon
output:
  html_notebook:
    toc: TRUE
---
```

### Controlling the depth of the table of contents

The default table of contents depth for R Notebooks is `3`. This means that the first 3 levels of headers will be included in the table of contents; i.e., headers created using `#`, `##`, and `###`. That may be too many or too few depending on the audience of the output document. Let's change the depth to `2`.

When using multiple options within `html_notebook`, we continue with new line breaks but don't indent any further. All the arguments that are specific to `html_notebook` will then line up in our YAML header in a single column.

```
---
title: "Practice Notebook"
date: May 16, 2018
author: Ariel Muldoon
output:
  html_notebook:
    toc: TRUE
    toc_depth: 2
---
```

### A floating table of contents

In HTML R Markdown documents such as Notebooks, we can allow the table of contents to "float". This means it will move when we scroll through the document. This is controlled via `toc_float`, which by default is `FALSE`.

You cannot have a floating table of contents in a static document such as a PDF document. If you go to the help page for `pdf_document`, you will see that `toc_float` is not an option.

```
---
title: "Practice Notebook"
date: May 16, 2018
author: Ariel Muldoon
output:
  html_notebook:
    toc: TRUE
    toc_depth: 2
    toc_float: TRUE
---
```

There are additional options to control what the floating table of contents looks like. By default it is *collapsed*, which isn't always ideal. See the link I gave above for an example of adding sub-options to the `html_document` options.

### Remove figure captions

We can get rid of captions on images via the `fig_caption: FALSE` option of the YAML header. Let's do that now. Upon previewing, we will see the caption is gone on our RStudio logo image.

```
---
title: "Practice Notebook"
date: May 16, 2018
author: Ariel Muldoon
output:
  html_notebook:
    toc: TRUE
    toc_depth: 2
    toc_float: TRUE
    fig_caption: FALSE
---
```

### Figure height and width in the YAML header doesn't work for R Notebooks

You see in the help document for `html_notebook` that there are options for controlling `fig_width` and `fig_height`. However, those do not currently work with R Notebooks. We will instead control figure height and width via chunk options.

## Code chunks

Now that we've gotten the text and formatting bits out of the way, let's get down to business and talk about the code chunks. We will be writing code chunks in R, although you can write and include output from code chunks from other languages such as Python and Stan in R Markdown documents.

We'll start by including a code chunk to load packages. I often have a chunk like this at the beginning of a document. We'll load some packages I know we have installed in this room. If you're on your own computer, you may need to install these.

As our initial document tells us, we can insert a new chunk using *Ctrl+Alt+I* (Mac OS *Cmd+Option+I*). We can also simply type out the ` ``` ` and `{r}` ourselves.

The code chunk will look like this:

~~~
```{r}
library(ggplot2)
library(dplyr)
```
~~~

Let's run the chunk. We see the green line, indicating R is running through the lines of code.

In this case, we also see the output, which is a warning about the R version and then several messages we get from **dplyr**.

```r
library(ggplot2)
library(dplyr)
```

```


Attaching package: 'dplyr'


The following objects are masked from 'package:stats':

    filter, lag


The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

### Options to control chunk output

These package messages can be important, but there are times when we might not want them in our final document. We can control what and how chunks print using the options provided by the **knitr** package. This package is what's working under the hood to put the R output in our output document.

There are, perhaps unsurprisingly, a ton of chunk options. The author of the **knitr** package, Yihui Xie, goes through the chunk options on his website, https://yihui.name/knitr/options/. I often end up reading through these when I'm trying to figure out how to get the output I want.

#### Suppressing messages and warnings: the `message` and `warning` options

We can keep messages from printing with the `message` option. This option is logical, and defaults to `TRUE`, meaning messages are printed in the chunk output. Below is the description of `message`.

> message: (TRUE; logical) whether to preserve messages emitted by message() (similar to warning)

If we want to remove messages we need to set message to `FALSE` in the *chunk header*. The chunk header is everything that is within the curly braces at the beginning of the chunk.

If we get output like `package dplyr was built under R version 3.3.3`, that's a *warning*, not a *message*. We control warnings with the `warning` option. This is also logical and also defaults to `TRUE`. See also the `error` option.

> warning: (TRUE; logical) whether to preserve warnings (produced by warning()) in the output like we run R code in a terminal (if FALSE, all warnings will be printed in the console instead of the output document); it can also take numeric values as indices to select a subset of warnings to include in the output

R Notebooks are interactive, meaning the code is run in real time. So before we can test if the output has changed when we change the chunk header, we need to unload the packages via `detach`. Then we can load them again to see if the chunk options worked.

```r
detach("package:dplyr", unload = TRUE)
detach("package:ggplot2", unload = TRUE)
```

Now that the packages are detached, we will rerun the package chunk after adding `message = FALSE` in the chunk header. We add these within the curly braces. It's common to put a comma after `r` before writing the chunk options. This has to do with naming chunks, which we will discuss later.

Here is what the new code chunk looks like.

~~~
```{r, message = FALSE}
library(dplyr)
library(ggplot2)
```
~~~

Now when we run this, we'll see the green line showing code is running in our R Notebook but we will not get the message in our output.

```r
library(ggplot2)
library(dplyr)
```

### Suppressing code output: the `eval` option

Sometimes we are going to write a chunk to show R code in our output, but we don't actually want the code to run or the output to be included in the final document. We can use `eval` for this.

> eval: (TRUE; logical) whether to evaluate the code chunk; it can also be a numeric vector to select which R expression(s) to evaluate, e.g. eval=c(1, 3, 4) or eval=-(4:5)

This is less common to use in an R Notebook than other R Markdown documents, as usually we specifically want the output to show in final document. However, I use this a lot for teaching documents where I'm doing something like showing code to go to a help page that I don't actually want to run.

As an example, sometimes I want to put some tabular output into a nicer looking table rather than using the default R output. So while I want my audience to see the R code used to make the tabular output, I use other tools to make the table look more attractive in the document. In this case I need to suppress the code output from the code chunk.

We can see this by making a summary dataset with **dplyr**.

~~~
```{r}
mtcars %>%
    group_by(cyl) %>%
    summarise(mdisp = mean(disp) )
```
~~~

```r
mtcars %>%
    group_by(cyl) %>%
    summarise(mdisp = mean(disp) )
```

```
# A tibble: 3 x 2
    cyl mdisp
  <dbl> <dbl>
1  4.00   105
2  6.00   183
3  8.00   353
```

I can suppress the output to show the code output in a different format. This can be one adding `eval = FALSE` to the chunk header.

~~~
```{r, eval = FALSE}
mtcars %>%
    group_by(cyl) %>%
    summarise( mdisp = mean(disp) )
```
~~~

We run the code and it still shows up in our `Rmd` file. However, when we look at the preview we see the summary output doesn't show since the code wasn't evaluated.

```
mtcars %>%
    group_by(cyl) %>%
    summarise( mdisp = mean(disp) )
```

We'll expand on this example later in the workshop to show a simple way to make a nicer looking table as output.

#### Suppressing code: the `echo` option

I commonly find I want to show output but not code when making R Markdown documents. This is what the `echo` option is for. See the similar `include` option, as well.

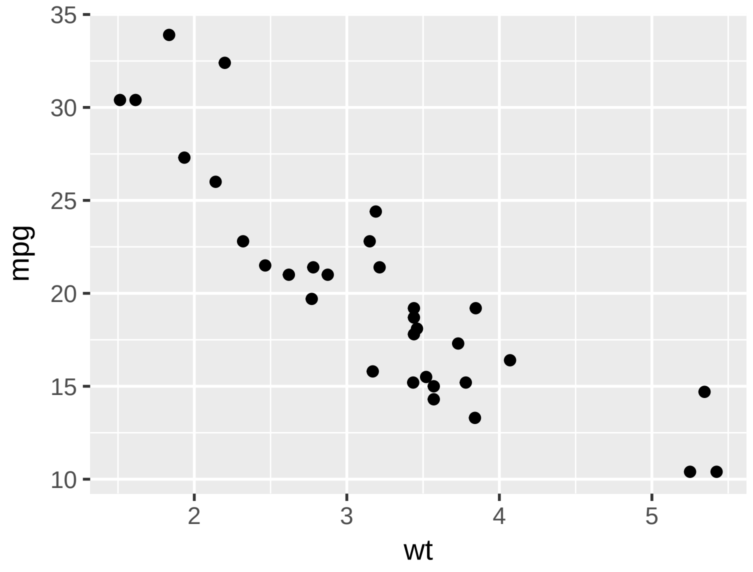
> echo: (TRUE; logical or numeric) whether to include R source code in the output file; besides TRUE/FALSE which completely turns on/off the source code, we can also use a numeric vector to select which R expression(s) to echo in a chunk, e.g. echo=2:3 means only echo the 2nd and 3rd expressions, and echo=-4 means to exclude the 4th expression

A plot is something we'd commonly want in our output but, depending on our audience, we may not want to show the R code that made the plot.

Let's make a plot using the built-in dataset mtcars.

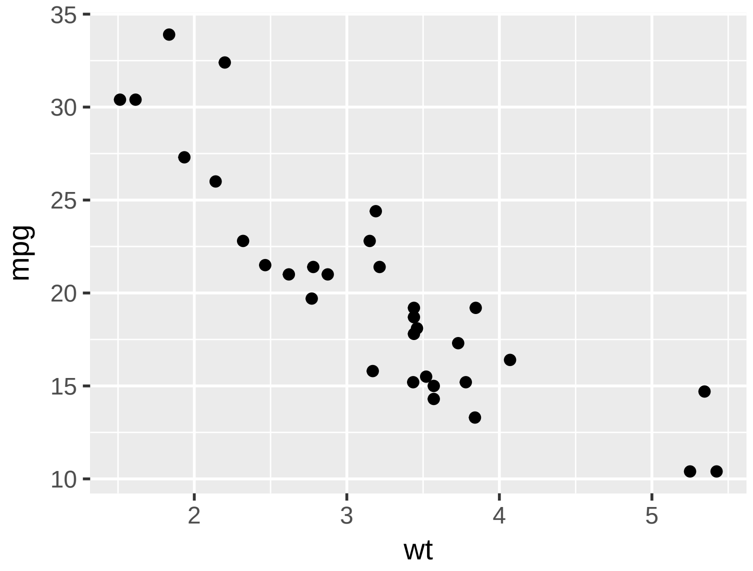
~~~
```{r}
qplot(wt, mpg, data = mtcars)
```
~~~

```
qplot(wt, mpg, data = mtcars)
```



If we wanted to show only the plot, without showing the code, we'll use `echo = FALSE` in the chunk header.

~~~
```{r, echo = FALSE}
qplot(wt, mpg, data = mtcars)
```
~~~



**Controlling figure size**

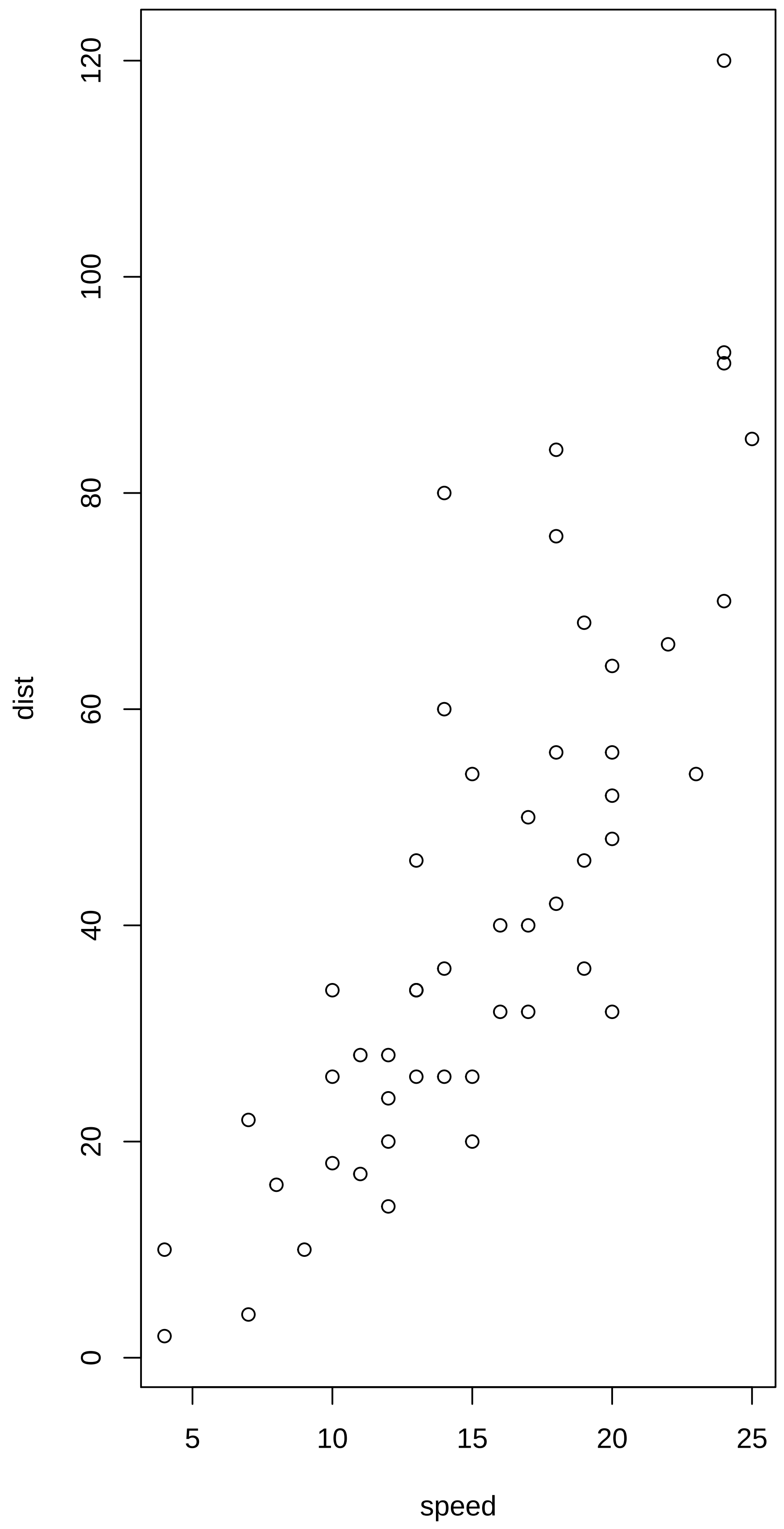
R Notebooks have a specific figure height and width. While we can't control figure size in R Notebooks via the YAML header, we can control figure size via chunk options.

Let's make the `cars` plot from the beginning of our practice notebook, but change the size of the figure. We do this via `fig.height` and `fig.width`, setting the numeric size of the plot in inches.

~~~
```{r, fig.height = 10, fig.width = 5}
plot(cars)
```
~~~

The plot is now much taller and skinnier than our original plot.

```r
plot(cars)
```


dist
0
20
40
60
80
100
120
5
10
15
20
25
speed

There are many more chunk options than we have time to talk about today. We'll explore just a couple more, but we will wait until we switch to working with an R Markdown document that is not a Notebook.

## The setup chunk

Sometimes we may want to set the same chunk option for every chunk in the document, which can be tedious. We can instead set options overall in the *setup* chunk using `opts_chunk$set` from **knitr**.

The setup chunk goes at the top of a `Rmd` document, right under the YAML header. We won't want anyone to see that code in the final document, so we'll use `echo = FALSE` in the setup chunk header.

It's also nice to name the chunk so we (and R) will know it's the setup chunk and can jump to it if we need. We can name a chunk by typing a name (that contains no spaces) after the `r` in the chunk header. The name goes before the comma for the chunk options.

### Making a setup chunk

In our practice setup chunk we'll set the plot size for all plots to be the same. We'll add the setup chunk below to the top of our practice `Rmd` file. As `opts_chunk` comes from package **knitr**, we load that package.

~~~
```{r setup, echo = FALSE}
library(knitr)
opts_chunk$set(fig.height = 10, fig.width = 5)
```
~~~

### Running all chunks again after adding a setup chunk

Once we've created the setup chunk we'll want to rerun all the chunks in our `Rmd` prior to previewing. This is because our R Notebook is interactive, and the output we've already created in the document won't change until we run the chunk again. I've had a hard time remembering this behavior of R Notebooks, and have wondered why a chunk option was having no effect on the output. We must always rerun a chunk in an R Notebook to see any changes.

We can run all current chunks by choosing *Run All Chunks* under the *Run* button or by using the keyboard short-cut *Ctrl+Alt+R* (OS X *Command+Option+R*).

# Default working directory for R Markdown documents

The default working directory for R Notebooks and all other R Markdown documents is the directory where the `Rmd` file is stored. This allows us to write all directory paths *relative* to that directory. This is helpful if we've organized things in such a way that our `Rmd` file is in the *root* directory, i.e., the overall directory that your project data/scripts are stored in.

We can check this by adding and running a chunk to get the working directory, `getwd`, within our `Rmd` file. Remember, we purposely did *not* set the working directory to the folder we are working in at the beginning of the workshop.

~~~
```{r}
getwd()
```
~~~

Run `getwd()` in the Console to see where the default working directory is for RStudio compared to the default working directory of our R Notebook.

## Reading a dataset based on the default working directory

Knowing that our `Rmd` file sets the default working directory to the directory it is located in allows us to organize our file structure in such a way to take advantage of that default. I sent you a file called `test.csv` that I asked you to save in a folder called `Data` in the folder you are working in today (the folder you are working in today is where you saved your `Rmd` file). Let's read that dataset in now.

When reading from a folder within our directory, we don't have to write out the entire directory path. Instead, we can write out the path starting at the folder within the default directory. You can see how that looks below. The `.` indicates the directory path to the default directory, so we add on the folder and document name to that path.

```r
dat = read.csv("./Data/test.csv")
dat
```

```
  Diffmeans Lower.CI Upper.CI plantdate stocktype
1     -0.27    -0.63     0.09      Jan2      cont
2      0.11    -0.25     0.47     Jan28      cont
3     -0.15    -0.51     0.21     Jan28      bare
4     -1.27    -1.63    -0.91     Feb25      cont
5     -1.18    -1.54    -0.82     Feb25      bare
```

### Changing to a different default directory

There are package options that can be set via **knitr** that allows us to change the overall defaults, which we could do in the setup chunk using `opts_knit$set`. This is a lot like how we set our chunk options. To change the default directory we can use `root.dir` and define a new file path.

> root.dir: (NULL) the root directory when evaluating code chunks; if NULL, the directory of the input document will be used

The `setwd` function you may be used to using will not work in an R Markdown document. If you are working with a more complicated directory structure but are taking advantage of RStudio Projects, using `root.dir` and `here::here()` together can be useful for setting the root directory without hard-coding the default file path. Here is what the code you add to the `setup` chunk could look like (using an actual file path where I wrote "filepath"): `knitr::opts_knit$set(root.dir = "filepath")`.

Working with relative paths instead of hard-coding paths is desirable. It allows for portability and reproducibility. If you haven't already, see the information about relative file paths here and check out the **here** package.

## Other R Notebook features

We're going to switch to working on another kind of R Markdown document, but we'll first cover a few more things that are specific to R Notebooks.

### Restarting an R Notebook after closing your R session

Remember that R Notebooks are interactive, as they are meant to mirror a scientific notebook. This means you run code and see the code output within the document, and the final document is based on the code you've actually run. If you go back to a Notebook that you've already started after ending the session, you may need to run some or all of the chunks before you can get do with any new R work that is based on previous work in the document. The *Run* button at the top of the document has many options, and the buttons within each chunk have options, such as *Run All Chunks Above*, for this reason.

### Separating single code chunks into multiples

When working with R Notebooks, it is most common to place any code that creates R output into a single chunk rather than having multiple outputs from a single chunk. This has to do with the scientific notebook/literate programming nature of Notebooks, where you are describing what you are doing with the analysis/code/output in plain text. If you have two lines of code in a single chunk, as shown below, you can easily separate them into two chunks by highlighting one of the lines of code and then using *Ctrl+Alt+I*. This remove that line of code and puts it into a new chunk.

For example, I might have copied and pasted and code chunk into my document with two plots in it.

~~~
```{r}
qplot(disp, mpg, data = mtcars)
qplot(wt, mpg, data = mtcars)
```
~~~

If I want to separate this into separate chunks so I can easily comment on the two plots in text, I could highlight the second line of code, `qplot(wt, mpg, data = mtcars)`, and use the chunk keyboard shortcut or *Insert* button to get two chunks:

~~~
```{r}
qplot(disp, mpg, data = mtcars)

```

```{r}
qplot(wt, mpg, data = mtcars)
```
~~~

## Embedding interactive graphics

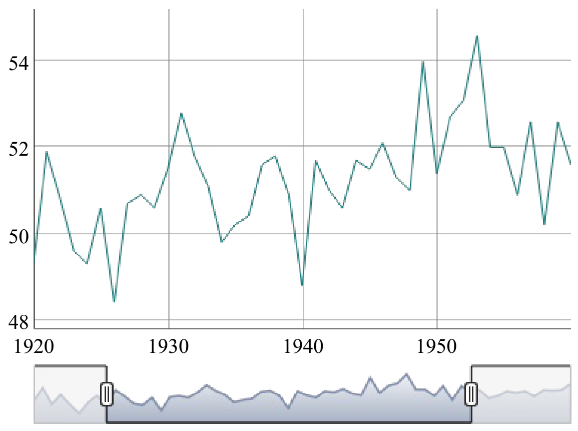
Another thing we can do with R Notebooks is to insert interactive graphics into our `Rmd` and our output HTML using packages such as **dygraphs** or **plotly** (note: **plotly** graphs don't always work well in Firefox, but display fine in, e.g., Chrome). Other HTML-producing Markdown documents can also include interactive graphics in the output. Interactive graphics can be a valuable tool for exploring the dataset and including them in an R Notebook allows us to share these with our collaborators without, e.g., making and uploading a Shiny app.

Here is a plot, made using the `dygraph` function from the **dygraphs** package, that allows the limits of the x axis to change interactively via a slider. The values of the x and y axis are shown in a tooltip when you hover over the plot. You may need to install **dygraphs** prior to running this code if you've never used this package before.

Generally a plot made with `dygraph` will be a time series, although it can be numeric. See the documentation for more information.

If you are reading the PDF version of this document, this plot will not be interactive but instead will be a small, static graphic.

```r
library(dygraphs)
dygraph(nhtemp) %>%
    dyRangeSelector( dateWindow = c("1920-01-01", "1960-01-01") )
```



### Re-running all chunks

When I make a Notebook for teaching purposes, I usually do a quick spell check using the *ABC* button, save everything, and then use the *Run* option *Restart R and Run All Chunks*. I do this to ensure all my code works properly in a clean R session in case I did something in R during my interactive work that I didn't explicitly include in the Notebook. This works well for relatively small documents, and is valuable when I'm making a document to send to someone else that needs to work exactly as I have written it.

If you have a very large document that has R processes that take a long time to run, you likely won't make use of this option as often. One of the good thing about an R Notebook is that once you've run something and produced output you have it in the document (both in the `Rmd` and the `nb.html` after saving). This makes it so you don't need to run the chunk every time you update the document.

## Create a PDF Markdown document

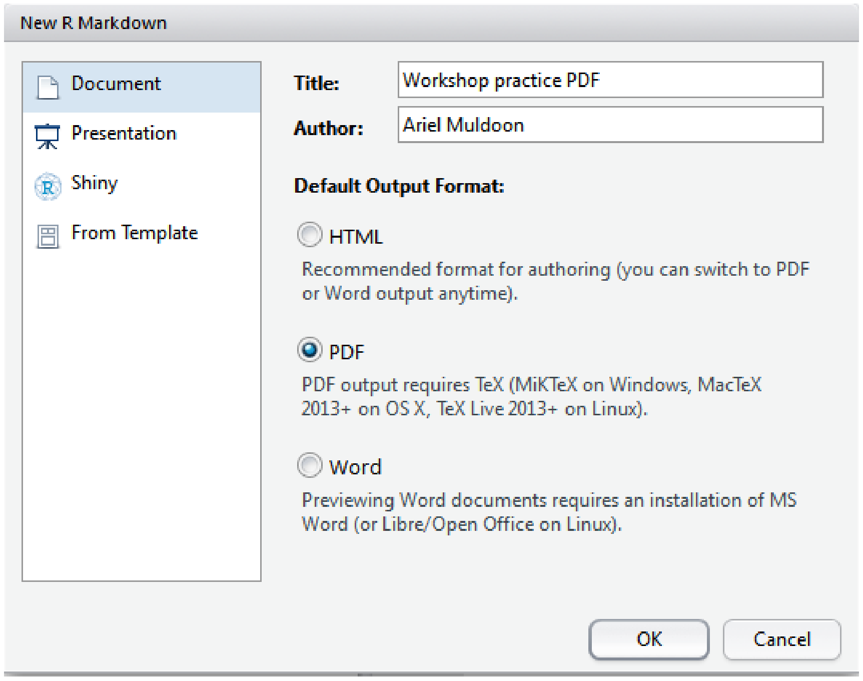
Let's close our Notebook and switch gears to working with another R Markdown document. This time we'll make a document that we will convert to a PDF.

To easily create a new Markdown document in RStudio, go to

> File > New File > R Markdown...

You will get a pop-up window to ask what type of Markdown file you want to make (Document, Presentation, Shiny or From Template) and what kind of default output format you want (HTML, PDF, or Word). You can also fill in the title and author for the YAML header.

We'll choose to make a Markdown document with a PDF output. We will not be talking about the other file types today. We'll fill in the title and author info today but we could delete them both to leave the YAML header blank.



Title: Workshop practice PDF

Author: Ariel Muldoon

Default Output Format:

( ) HTML
Recommended format for authoring (you can switch to PDF or Word output anytime).

(●) PDF
PDF output requires TeX (MiKTeX on Windows, MacTeX 2013+ on OS X, TeX Live 2013+ on Linux).

( ) Word
Previewing Word documents requires an installation of MS Word (or Libre/Open Office on Linux).

Press OK and we get a new, untitled document in our Source Pane. It also has default text and code, so we'll start by taking a closer look at those.

## YAML header

The included YAML header is very similar to our YAML header when we opened the new Notebook. Because we filled in a title and author, those are filled in. We also get the `date`. Any of these can be removed as desired.

The primary difference is in the document type listed under `output`. Before we had a `html_notebook`; now we have a `pdf_document`.

Our initial YAML header for a PDF Markdown document looks like:

```
---
title: "Workshop practice PDF"
author: "Ariel Muldoon"
date: "May 16, 2018"
output: pdf_document
---
```

## Setup chunk

You can see the first chunk is a setup chunk. This is included by default in new documents because it is so common to have one. This particular setup chunk doesn't do much, but it can easily be added to. Notice that it uses `include = FALSE` instead of `echo = FALSE` to suppress the setup code from the output document

~~~
```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
```
~~~

There are two other chunks in the default document. If we run them we do get output to show within the document by default. However, running or not running chunks interactively will not affect our output document. We won't run these chunks right now so we can see what happens in the output.

Note that you can stop output from showing within the `Rmd` document by going to

> Global Options… > R Markdown

and unclick the box next to `Show output inline for all R Markdown documents`

## R Markdown with PDF output

Instead of a *Preview* button at the top of the document, we now have a *Knit* button. This is what we will use to *knit* the `Rmd` file to the output type we've chosen. In this case we'll be knitting this document to a PDF, as we chose a `PDF` document when we created the new R Markdown file.

This process is called knitting because the **knitr** package is doing the work behind the scenes.

### Saving the R Markdown document

If you hit *Knit*, you will be prompted to save the document. Let's save this as a document called `pdf_test.Rmd`.

Once you hit *Save* the document will immediately begin to knit. We can see the process in the R Markdown pane in RStudio, which shows in the same pane as the Console. This is RStudio using various R packages and software to do the heavy lifting of converting our `Rmd` to a PDF.

You'll see RStudio keeps track of how much of the document has been knit. For small documents it seems almost instantaneous, but for larger documents this can help you keep track of the progress that has been made.

### Knitting to PDF requires LaTeX

RStudio does this knitting in a way that looks pretty magical. However, we need a LaTeX program installed if we want to knit a Markdown document to a non-HTML format, which is why we installed TinyTeX earlier. Other common LaTeX distributions are MikTeX (Windows) and MacTeX (Mac OS).

If you do not have some version of LaTeX installed or RStudio can't find the one you do have, you will get errors when trying to knit to non-HTML formats and you will need to troubleshoot.

### The output PDF document

Once the PDF document has been created, we can take a closer look at it. You'll see all the same elements as our R Notebook, including information from the YAML header, plain text, and code with output.

#### Code chunks always create output by default

One thing I want you to see is that our two non-setup R code chunks both ran and the R output shows in the PDF document. This is one big difference between interactive R Markdown Notebooks and non-interactive (or *batch*) R Markdown documents.

In the former, we run chunks interactively and they show up in the final document. The document is updated each time you save, but doesn't run through any chunks that have already been run and saved previously.

In the latter, all code chunks are run every time you knit. The order the chunks are in is very important, as the chunks are run in the order they show up in the document. This means you must have a code chunk that loads a package before a code chunk that uses functions from that package.

For large R Markdown documents with a lot of slow code, running all chunks every time you knit can get tiresome. The chunk option `cache = TRUE` can help with this, allowing the output to be *cached* after it is run the first time to save on processing time. See the caching page on the **knitr** author's website for more info.

#### Removing pound signs from code output via setup chunk

If you look at the code output in the PDF, you'll see each line is prefaced by two pound signs (`##`). My personal preference is to remove those, and so I usually include `comment = NA` in the setup chunk to get rid of those.

We can change the setup chunk and re-knit to see the effect.

~~~
```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE, comment = NA)
```
~~~

## YAML header options for PDF documents

As you already know, PDF documents have some distinct YAML header options. Review those here.

We can add YAML header options after `pdf_document`, much like we did in our Notebook earlier with `html_notebook`. See the help page for `pdf_document` for more information and some of the options, shown below.

> pdf_document(toc = FALSE, toc_depth = 2, number_sections = FALSE, fig_width = 6.5, fig_height = 4.5, fig_crop = TRUE, fig_caption = TRUE, dev = "pdf", df_print = "default", highlight = "default", template = "default", keep_tex = FALSE, latex_engine = "pdflatex", citation_package = c("none", "natbib", "biblatex"), includes = NULL, md_extensions = NULL, pandoc_args = NULL, extra_dependencies = NULL)

You see that there is no option for a floating table of contents. We can't have this kind of interactive element in static documents like a PDF document, although the table of contents and links will still be clickable.

While we won't cover it today, note there are options to add citations to a Markdown document; if you are interested see here to get started. See also package **bookdown**.

### Add table of contents

We won't do much with more with the YAML header than we have already, but we will add a table of contents to the top of the document based on the headers. Notice that we once again change the format of the header to add the indentations and line breaks. Page numbers for each header are included in the table of contents.

```
---
title: "Workshop practice PDF"
author: "Ariel Muldoon"
date: "May 16, 2018"
output:
  pdf_document:
    toc: TRUE
---
```

### Change the document margins

Other things I often change are things like the margins of the document. I find this especially true when trying to get figures to fit nicely without leaving large blank spaces. Sometimes making the margins a little wider or narrower really helps. Margins can be changed via `geometry`, setting the margins overall or just some of the margins. Here we'll change all the margins to 0.5 inches except the bottom margin, which will be set to 0.75 inches.

```
---
title: "Workshop practice PDF"
author: "Ariel Muldoon"
date: "May 16, 2018"
geometry: margin=.5in, bottom=.75in
output:
  pdf_document:
    toc: TRUE
---
```

### Make URL links visible

In the HTML document, URL links were blue, so were easy to see. If you take a look at the PDF output document, you can see the URL is clickable if you hover over it but otherwise it looks like the rest of the text. We can make these more visible by changing the color using the `urlcolor` option in the YAML header. Today we'll make URL links blue.

```
---
title: "Workshop practice PDF"
author: "Ariel Muldoon"
date: "May 16, 2018"
geometry: margin=.5in, bottom=.75in
urlcolor: blue
output:
  pdf_document:
    toc: TRUE
---
```

## More chunk options

Let's add a couple more code chunks so we can practice using chunk options.

### A situation to use `eval` and `echo`

I outlined a situation earlier where I sometimes use `eval`. This is where I want to show the code for some tabular output, but want the output to look nicer than it does by default. I can make the nicer output using a second chunk of code, suppressing the code in that chunk from the output document using `echo`.

Let's load **dplyr** here and remake that little summary table from earlier. All packages used within the R Markdown document need to be loaded, regardless of if you've already loaded them interactively in your R session.

We still use *Ctrl+Alt+I* for inserting new code chunks in our new R Markdown document.

Below are what the three chunks could look like.

1. I load the package, using `message = FALSE` to suppress the loading messages.

2. I write the summary table code to include in the document, but suppress the output via `eval = FALSE`.
3. I make a nicer looking table in the output using the `kable` function from package **knitr**. I don't want the code I use for this to show in the document, so I use `echo = FALSE`.

The `kable` function is a relatively simple function with few options, but the output tables can be pretty nice looking without much work in a PDF document.

~~~
```{r, message = FALSE}
library(dplyr)
```

```{r, eval = FALSE}
mtcars %>%
    group_by(cyl) %>%
    summarise(mdisp = mean(disp) )
```

```{r, echo = FALSE}
knitr::kable(mtcars %>%
    group_by(cyl) %>%
    summarise(mdisp = mean(disp) ) )
```
~~~

The code and output is below, although the effect will not be the same if you are reading this in an `nb.html` document compared to a PDF document.

```r
library(dplyr)
```

```r
mtcars %>%
    group_by(cyl) %>%
    summarise( mdisp = mean(disp) )
```

| cyl | mdisp |
|---:|---:|
| 4 | 105.1364 |
| 6 | 183.3143 |
| 8 | 353.1000 |

## Holding figures to end of chunk with `fig.show`

If making several plots in one code chunk, we can either allow each to show after the line of code has run or hold all of the plots until the end of the chunk based on `fig.show`. By default, each plotted as soon as its line of code has been run.

> fig.show: ('asis'; character) how to show/arrange the plots; four possible values are -asis: show plots exactly in places where they were generated (as if the code were run in an R terminal); -hold: hold all plots and output them in the very end of a code chunk; -animate: wrap all plots into an animation if there are mutiple plots in a chunk; -hide: generate plot files but hide them in the output document

Let's make two plots in one code chunk. After knitting we see what happens by default, which is that we see the plot shown immediately after the line of code that produced it.

~~~
```{r}
plot(cars)
plot(pressure)
```
~~~

Using `fig.show = "hold"`, we *hold* all plots to be produced at the end of the chunk. This *does not* work in R Notebooks so I don't show the output here.

~~~
```{r, fig.show = "hold"}
plot(cars)
plot(pressure)
```
~~~

If we change the width of the figures, we can get them to fit next to each other. This saves us some space.

~~~
```{r, fig.show = "hold", fig.width = 4}
plot(cars)
plot(pressure)
```
~~~

## Naming chunks

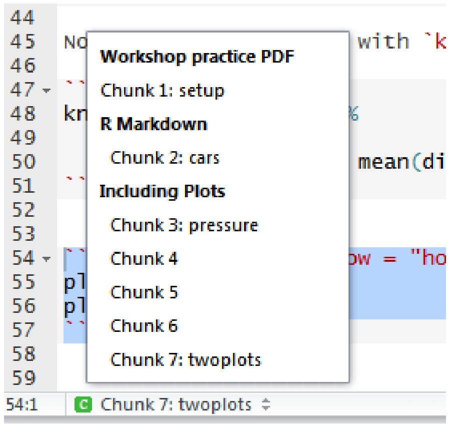
We named the setup chunk earlier, but haven't talked any more about naming chunks. I name chunks in most of my long Markdown documents, as it improves my ability to jump around in the document.

Each chunk must have a unique name. If you make the mistake of repeating a chunk name you will get an error on knitting. Let's add a chunk name to our last code chunk. We'll name it `twoplots`. We add this after the `r` but before the comma in the chunk header.

~~~
```{r twoplots, fig.show = "hold", fig.width = 4}
plot(cars)
plot(pressure)
```
~~~

### Chunk names in the navigation bar

When you click on the navigation bar in the lower left corner of the document, you can see all headers and chunks. The chunks are numbered by default, and when we add names, the names are also be listed. This can make organization and navigation within an R Markdown document easier.



### Chunks with the same name

To see what happens when two chunks have the same name, change the last chunk name to `pressure`. There is already a chunk named `pressure` in this document. Now attempt to knit the document.

We see an error in the R Markdown pane:

> processing file: pdf_test.Rmd Error in parse_block(g[-1], g[1], params.src) : duplicate label 'pressure' Calls: … process_file -> split_file -> lapply -> FUN -> parse_block Execution halted

Among all the other words, the error clearly tells us we have a duplicate label and what that label is, allowing us to go and fix it.

## Knitting errors

What about other knitting errors? If we have R code that has an error in it and won't run, the knitting will fail. The message we get will look difficult to read initially, but it does indicate a line number within the `Rmd` file as a starting point for finding the error.

Change the last chunk name back to `twoplots`, and remove the closing parenthesis in one line of plot code. Failing to close parentheses in R means code can't finish running.

~~~
```{r twoplots, fig.show = "hold", fig.width = 4}
plot(cars)
plot(pressure
```
~~~

In the *Output* part of the R Markdown pane we'll see an error message directly after R attempted to run the `twoplots` chunk. This is where chunk names can once again be helpful. We also get the line numbers of the chunk that is causing issues.

> Quitting from lines 55-57 (pdf_test.Rmd) Error in parse(text = x, srcfile = src) : :3:0: unexpected end of input 1: plot(cars) 2: plot(pressure ^ Calls: … evaluate -> parse_all -> parse_all.character -> parse Execution halted

In the *Issues* part of the pane we'll see a line number and the same message written again. This line number is the first line of the chunk that is causing the issue. We can now navigate to that chunk and see if we can figure out what the problem is.

## Knitting an R Notebook to a PDF

The last thing we'll do is go back to our practice notebook file, `notebook_test.Rmd`, and knit it to a PDF. The HTML output notebook has a lot of good things about it, including the way the `Rmd` file is embedded in it. However, HTML files tend not to be very good for printing and sometimes we'll want to take the file and make a PDF file in addition to the `nb.html` file.

We can knit to a PDF by going to the drop down menu arrow next to *Preview* and choosing *Knit to PDF*. However, we have several elements in the R Notebook that work for HTML output that won't work well for a static PDF output. Let's make a few changes before proceeding.

### Change how static images are added

Inserting images via the Markdown language as we did earlier doesn't always work well for PDF output documents. Images aren't necessarily placed exactly where you put them but instead the computer places them wherever it finds enough space.

A convenient alternative is to use R code to insert graphics using `insert_graphics()` from package **knitr** instead of using Markdown syntax. The width of the output is controlled by the code chunk option `out.width` and the code can be suppressed using `echo = FALSE`.

Here is what the code looks like to insert the RStudio logo via **knitr**, which will replace our R Markdown syntax. As this also works for HTML output formats, this is likely the best default option for inserting images. Remember that for `nb.html` output files we'll need to run this code before the image will appear in the output.

~~~
```{r, echo = FALSE, out.width = "100%"}
knitr::include_graphics('RStudio-Logo-Blue-Gradient.png')
```
~~~

Using this option puts the image right where you want it, regardless of the output document type. I put mine below.

### Making interactive plots static while knitting

Interactive graphics only work for HTML output files. If we try to knit to a PDF document with an interactive graphic we'll see an error message:

> Error: Functions that produce HTML output found in document targeting latex output. Please change the output type of this document to HTML. Alternatively, you can allow HTML output in non-HTML formats by adding this option to the YAML front-matter of your rmarkdown file:
>
> always_allow_html: yes
>
> Note however that the HTML output will not be visible in non-HTML formats.
>
> Execution halted

**Use `always_allow_html` in the YAML header**

One option to avoid problems of interactive graphs in static documents is to add `always_allow_html: yes` to our YAML header. This suppresses the interactive graphic in the resulting static document, so it simply doesn't print at all.

Adding that would look like:

```
---
title: "Practice Notebook"
date: May 16, 2018
author: Ariel Muldoon
always_allow_html: yes
output:
  html_notebook:
    toc: TRUE
    toc_depth: 2
    toc_float: TRUE
    fig_caption: FALSE
---
```

**Use package webshot**

The nicer option is it install package **webshot** and the install PhantomJS with `webshot::install_phantomjs()`. This allows **knitr** to take a static image of our interactive graphic and include it in the PDF. If we use this option we don't need to add anything to the YAML header.

## Make URL links visible

If we have URL links in our document, we might want to use the `urlcolor` YAML header option to make URL links visible.

```
---
title: "Practice Notebook"
date: May 16, 2018
author: Ariel Muldoon
urlcolor: blue
output:
  html_notebook:
    toc: TRUE
    toc_depth: 2
    toc_float: TRUE
    fig_caption: FALSE
---
```

Once we've made the changes outlined above, we can knit things to a PDF via the drop down menu. RStudio edits the YAML header for us to indicate we are now knitting to a PDF document. You'll see we have a second `output` type listed.

Once we *Knit to PDF*, the `pdf_document` output is listed first and the YAML header looks like what's printed below. RStudio also changed some of our `TRUE`/`FALSE` to `yes`/`no`, but that doesn't change the resulting document.

```
---
title: "Practice Notebook"
author: "Ariel Muldoon"
date: "May 16, 2018"
output:
  pdf_document:
    toc: yes
    toc_depth: '2'
  html_notebook:
    fig_caption: no
    toc: yes
    toc_depth: 2
    toc_float: yes
urlcolor: blue
---
```

We could make further changes to the YAML header that are specific to the PDF document output, as needed.

To go back to the HTML output, we switch the order of the output in the YAML header manually or choose *Preview Notebook* from the drop down menu.

## Navigating with the outline side-bar

In addition to the Navigation bar at the bottom that we saw when discussing code chunks, we can navigate through an R Markdown document via the headers by opening the outline side-bar. The default is to not show the outline (although this can be changed in *Global Options... > R Markdown*). I often use the outline to navigate, which can be opened by clicking on the button in the upper right corner of the R Markdown document:

## Options and links

I've given you a basic start to learn how to take advantage of R Notebooks and other R Markdown documents. While we didn't see it today, there is an option to knit `Rmd` files to Word documents.

These same tools can also be extended to making slides for presentations, allowing you to include R code and/or output within the rest of your slides.

### Informational links

Throughout this document outlining the workshop, I've given you links to pages that cover important material. I'll end by listing the complete address for each one here. There is a lot of information about these topics on the internet, and these are a good starting point if you get stuck.

#### Package tinytex

https://yihui.name/tinytex/

#### RStudio cheatsheet

https://www.rstudio.com/wp-content/uploads/2015/02/rmarkdown-cheatsheet.pdf

#### Markdown basics

http://rmarkdown.rstudio.com/authoring_basics.html

#### LaTeX mathematical symbols

https://oeis.org/wiki/List_of_LaTeX_mathematical_symbols

#### Formatting HTML documents

http://rmarkdown.rstudio.com/html_document_format.html#overview

**Formatting PDF documents**

http://rmarkdown.rstudio.com/pdf_document_format.html#overview

**knitr chunk options**

https://yihui.name/knitr/options/

**An argument for relative file paths**

https://www.tidyverse.org/articles/2017/12/workflow-vs-script/

**Chunk caching**

https://yihui.name/knitr/demo/cache/

**Adding citations**

http://rmarkdown.rstudio.com/authoring_bibliographies_and_citations.html