

# Getting Started with R Markdown

*By John on November 24, 2016*



## Tutorial Aims:

1. Understand what RMarkdown is and why you should use it
2. Learn how to construct an RMarkdown file
3. Export an RMarkdown file into many file formats

## Steps:

1. What is RMarkdown ?
2. Download RMarkdown
3. Create an RMarkdown ( .Rmd ) file
4. Identify the different parts of a .Rmd file
5. Insert code from an R script into a .Rmd file
6. Create a .pdf file from your .Rmd file
7. R Notebooks (the future of reproducible code? Maybe?)

## What is R Markdown?

R Markdown allows you to create documents that serve as a neat record of your analysis. In the world of reproducible research, we want other researchers to easily understand what we did in our analysis, otherwise nobody can be certain that you analysed your data properly. You might choose to create an RMarkdown document as an appendix to a paper or project assignment that you are doing, upload it to an online repository such as Github, or simply to keep as a personal record so you can quickly look back at your code and see what you did. RMarkdown presents your code alongside its output (graphs, tables, etc.) with conventional text to explain it, a bit like a notebook.

RMarkdown uses Markdown syntax (<http://www.markdowntutorial.com>). Markdown is a very simple 'markup' language which provides methods for creating documents with headers, images, links etc. from plain text files, while keeping the original plain text file easy to read. You can convert Markdown documents to many other file types like .html or .pdf to display the headers, images etc..

To see what RMarkdown is capable of, have a look at this undergraduate dissertation ([https://github.com/ourcodingclub/CC-2-RMarkdown/blob/master/UnderGrad\\_Dissertation\\_Rmd.pdf](https://github.com/ourcodingclub/CC-2-RMarkdown/blob/master/UnderGrad_Dissertation_Rmd.pdf)), which gives a concise log of their statistical analysis, or the completed demo RMarkdown file ([https://github.com/ourcodingclub/CC-2-RMarkdown/blob/master/RMarkdown\\_Tutorial\\_Demo\\_Rmd.Rmd](https://github.com/ourcodingclub/CC-2-RMarkdown/blob/master/RMarkdown_Tutorial_Demo_Rmd.Rmd)) for this tutorial.

All the resources for this tutorial, including some helpful cheatsheets can be downloaded from this repository (<https://github.com/ourcodingclub/CC-2-RMarkdown>). **Clone and download the repo as a zip file, then unzip it.**

**Read through this tutorial and use the information you learn along the way to convert the tutorial R script ( RMarkdown\_Tutorial.R ), which you can find in the repo, into a well commented, logically structured R Markdown ( .Rmd ) document. Afterwards, there are some challenge scripts that you can convert to .Rmd documents. If you want, you could also try converting one of your own R scripts.**

**Haven't used R or RStudio before? No worries! Check out our Intro to R and RStudio tutorial (<https://ourcodingclub.github.io/2016/11/13/intro-to-r.html>), then come back here to master RMarkdown !**

## Download R Markdown

To get `RMarkdown` working in RStudio, the first thing you need is the `rmarkdown` package, which you can get from CRAN (<https://cran.r-project.org/web/packages/rmarkdown/index.html>) by running the following commands in R or RStudio:

```
install.packages("rmarkdown")  
library(rmarkdown)
```

## Create an RMarkdown file

To create a new `RMarkdown` file ( `.Rmd` ), select `File -> New File -> R Markdown... _` in `RStudio` , then choose the file type you want to create. For now we will focus on a `.html Document` , which can be easily converted to other file types later.

The newly created `.Rmd` file comes with basic instructions, but we want to create our own `RMarkdown` script, so go ahead and delete everything in the example file.

Now save the `.Rmd` file to the repository you downloaded earlier from Github (<https://github.com/ourcodingclub/CC-2-RMarkdown>).

Now open the `RMarkdown_Tutorial.R` practice script from the repository you downloaded earlier in another tab in `RStudio` and use the instructions below to help you convert this script into a coherent `RMarkdown` document, bit by bit.

If you have any of your own `R` scripts that you would like to make into an `R Markdown` document, you can also use those!

## The different parts of an R Markdown file

### The YAML Header

At the top of any `RMarkdown` script is a `YAML` header section enclosed by `---` . By default this includes a title, author, date and the file type you want to output to. Many other options are available for different functions and formatting, see here for `.html` options

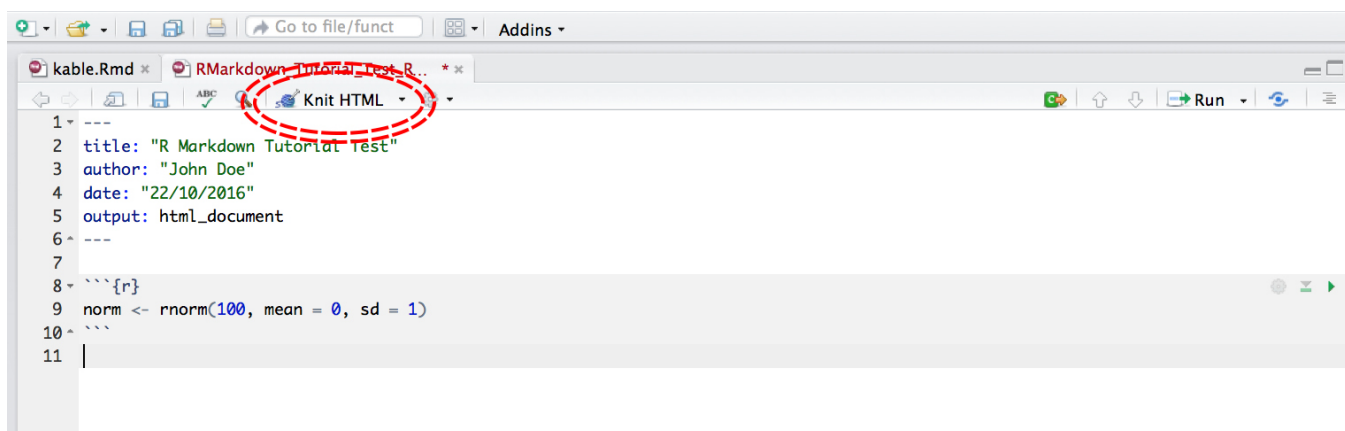
([http://rmarkdown.rstudio.com/html\\_document\\_format.html](http://rmarkdown.rstudio.com/html_document_format.html)) and here for `.pdf` options ([http://rmarkdown.rstudio.com/pdf\\_document\\_format.html](http://rmarkdown.rstudio.com/pdf_document_format.html)). Rules in the header section will alter the whole document. Have a flick through quickly to familiarise yourself with the sorts of things you can alter by adding an option to the `YAML` header.

Insert something like this at the top of your new `.Rmd` script:

```
---
title: "Edinburgh Biodiversity"
author: John Doe
date: 22/Oct/2016
output: html_document
---
```

By default, the `title`, `author`, `date` and `output` format are printed at the top of your `.html` document. This is the minimum you should put in your header section.

Now that we have our first piece of content, we can test the `.Rmd` file by compiling it to `.html`. To compile your `.Rmd` file into a `.html` document, you should press the `Knit` button in the taskbar:



By default, RStudio opens a separate preview window to display the output of your `.Rmd` file. If you want the output to be displayed in the `Viewer` window in RStudio (the same window where you would see plotted figures / packages / file paths), select "View in Pane" from the drop down menu that appears when you click on the `Knit` button in the taskbar, or in the `Settings` gear icon drop down menu next to the `Knit` button.

A preview appears, and a `.html` file is also saved to the same folder where you saved your `.Rmd` file.

## Code Chunks

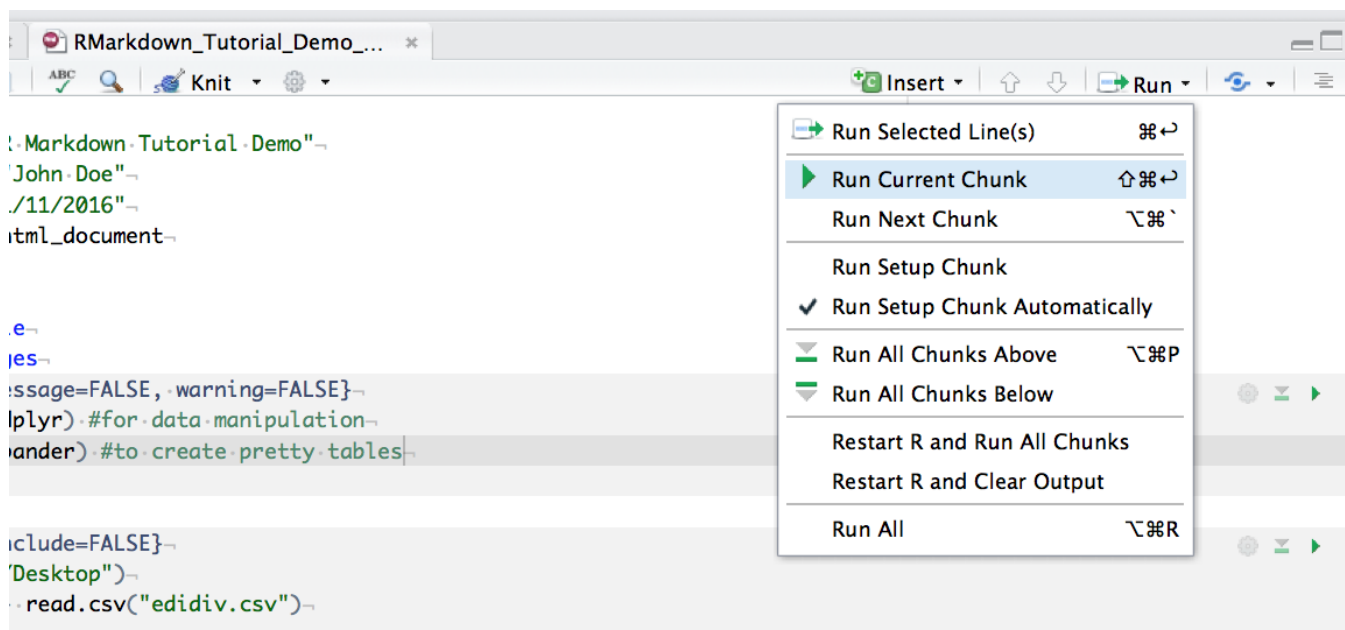
Below the `YAML` header is the space where you will write your code, accompanying explanation and any outputs. Code that is included in your `.Rmd` document should be enclosed by three backwards apostrophes ````` (grave accents!). These are known as code chunks and look like this:

```
```{r}
norm <- rnorm(100, mean = 0, sd = 1)
```
```

Inside the curly brackets is a space where you can assign rules for that code chunk. The code chunk above says that the code is R code. We'll get onto some other curly brace rules later.

**Have a go at grabbing some code from the example R script and inserting it into a code chunk in your `.Rmd` document.**

You can run an individual chunk of code at any time by placing your cursor inside the code chunk and selecting `Run -> Run Current Chunk`:



## More on Code Chunks

It's important to remember when you are creating an `RMarkdown` file that if you want to run code that refers to an object, for example:

```
```{r}
plot(dataframe)
```
```

you must include instructions showing what `dataframe` is, just like in a normal R script. For example:

```
```{r}
A <- c("a", "a", "b", "b")
B <- c(5, 10, 15, 20)
dataframe <- data.frame(A, B)
plot(dataframe)
```
```

Or if you are loading a dataframe from a `.csv` file, you must include the code in the `.Rmd` :

```
```{r}
dataframe <- read.csv("~/Desktop/Code/dataframe.csv")
```
```

Similarly, if you are using any packages in your analysis, you will have to load them in the `.Rmd` file using `library()` as in a normal R script.

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

## Hiding code chunks

If you don't want the code of a particular code chunk to appear in the final document, but still want to show the output (e.g. a plot), then you can include `echo = FALSE` in the code chunk instructions.

```
```{r, echo = FALSE}
A <- c("a", "a", "b", "b")
B <- c(5, 10, 15, 20)
dataframe <- data.frame(A, B)
plot(dataframe)
```
```

Similarly, you might want to create an object, but not include both the code and the output in the final `.html` file. To do this you can use, `include = FALSE`. Be aware though, when making reproducible research it's often not a good idea to completely hide some part of your analysis:

```
```{r, include = FALSE}
richness <-
  edidiv %>%
    group_by(taxonGroup) %>%
    summarise(Species_richness = n_distinct(taxonName))
```
```

In some cases, when you load packages into RStudio, various warning messages such as “Warning: package ‘dplyr’ was built under R version 3.4.4” might appear. If you do not want these warning messages to appear, you can use `warning = FALSE`

```
```{r, warning = FALSE}
library(dplyr)
```
```

**REMEMBER: R Markdown doesn’t pay attention to anything you have loaded in other R scripts, you MUST load all objects and packages in the R Markdown script.**

## More Code Chunk Instructions

| Rule                  | Example (default) | Function   |
|-----------------------|-------------------|--|
| eval                  | eval=TRUE         | Is the code run and the results included in the output?  |
| include               | include=TRUE      | Are the code and the results included in the output?   |
| echo                  | echo=TRUE         | Is the code displayed alongside the results?   |
| warning               | warning=TRUE      | Are warning messages displayed?  |
| error                 | error=FALSE       | Are error messages displayed?  |
| message               | message=TRUE      | Are messages displayed?  |
| tidy                  | tidy=FALSE        | Is the code reformatted to make it look “tidy”?  |
| results               | results="markup"  | <b>How are results treated?</b><br>"hide" = no results<br>"asis" = results without formatting<br>"hold" = results only compiled at end of chunk (use if many commands act on one object) |
| cache                 | cache=FALSE       | Are the results cached for future renders?   |
| comment               | comment="###"     | What character are comments prefaced with?   |
| fig.width, fig.height | fig.width=7       | What width/height (in inches) are the plots?   |
| fig.align             | fig.align="left"  | "left" "right" "center"  |

# Inserting Figures

Inserting a graph into RMarkdown is easy, the more energy-demanding aspect might be adjusting the formatting.

By default, RMarkdown will place graphs by maximising their height, while keeping them within the margins of the page and maintaining aspect ratio. If you have a particularly tall figure, this can mean a really huge graph. In the following example we modify the dimensions of the figure we created above. To manually set the figure dimensions, you can insert an instruction into the curly braces:

```
```{r, fig.width = 4, fig.height = 3}
A <- c("a", "a", "b", "b")
B <- c(5, 10, 15, 20)
dataframe <- data.frame(A, B)
plot(dataframe)
```
```

# Inserting Tables

## Standard R Markdown

While R Markdown can print the contents of a data frame easily by enclosing the name of the data frame in a code chunk:

```
```{r}
dataframe
```
```

this can look a bit messy, especially with data frames with a lot of columns. Including a formal table requires more effort.

## kable() function from knitr package

The most aesthetically pleasing and simple table formatting function I have found is `kable()` in the `knitr` package. The first argument tells `kable` to make a table out of the object `dataframe` and that numbers should have two significant figures. Remember to load the `knitr` package in your `.Rmd` file as well.



```
```\r\nlibrary(knitr)\nkable(dataframe, digits = 2)\r\n```
```

## pander function from pander package

If you want a bit more control over the content of your table you can use `pander()` in the `pander` package. Imagine I want the 3rd column to appear in italics:

```
```\r\nlibrary(pander)\nplant <- c("a", "b", "c")\ntemperature <- c(20, 20, 20)\ngrowth <- c(0.65, 0.95, 0.15)\ndataframe <- data.frame(plant, temperature, growth)\nemphasize.italics.cols(3)  # Make the 3rd column italics\npander(dataframe)          # Create the table\r\n```
```

Find more info on pander here (<https://cran.r-project.org/web/packages/pander/pander.pdf>).

## Manually creating tables using markdown syntax

You can also manually create small tables using markdown syntax.

For example:

```
Plant	Temp.	Growth
A	20	0.65
B	20	0.95
C	20	0.15
```

will create something that looks like this:

| Plant | Temp. | Growth |
|-------|-------|--------|
| A     | 20    | 0.65   |
| B     | 20    | 0.95   |
| C     | 20    | 0.15   |

The `:-----:` tells markdown that the line above should be treated as a header and the lines below should be treated as the body of the table. Text alignment of the columns is set by the position of `:` :

| Syntax                | Alignment |
|-----------------------|-----------|
| <code>`:-----`</code> | Centre    |
| <code>`:-----`</code> | Left      |
| <code>`-----:`</code> | Right     |
| <code>`-----`</code>  | Auto      |

## Creating tables from model outputs

Using `tidy()` from the package `broom`, we are able to create tables of our model outputs, and insert these tables into our markdown file. The example below shows a simple example linear model, where the summary output table can be saved as a new R object and then added into the markdown file.

```
```{r}
library(broom)
A <- c(20, 15, 10)
B <- c(1, 2, 3)

lm_test <- lm(A ~ B)           # Creating linear model
summary(lm_test)              # Obtaining linear model summary statistics

table_obj <- tidy(lm_test)     # Using tidy() to create a new R object called table
pander(table_obj, digits = 3)  # Using pander() to view the created table, with 3 sig figs
```
```

## Formatting Text

Markdown syntax can be used to change how text appears in your output file. Here are a few common formatting commands:

***\*Italic\****

*Italic*

**\*\*Bold\*\***

## Bold

This is ``code`` in text

This is `code` in text

# Header 1

# Header 1

## Header 2

## Header 2

Note that when a # symbol is placed inside a code chunk it acts as a normal R comment, but when placed in text it controls the header size.

\* Unordered list item

- Unordered list item

1. Ordered list item

1. Ordered list item

[Link](https://www.google.com)

Link (https://www.google.com)

```
$A = \pi \times r^{2}$
```

$$A = \pi \times r^2$$

The `$` symbols tell R markdown to use LaTeX equation syntax (<http://reu.dimacs.rutgers.edu/Symbols.pdf>).

## Creating .pdf files in Rmarkdown

Creating .pdf documents for printing in A4 requires a bit more fiddling around. RStudio uses another document compiling system called LaTeX (<https://www.latex-project.org/>) to make .pdf documents.

If you are using Windows, go to MikTeX (<https://miktex.org/download>) and download the appropriate “Complete MikTeX Installer” for your system, either 32-bit or 64-bit.

If you are using a Mac, go to MacTeX (<https://tug.org/mactex/mactex-download.html>) and download the “MacTeX.pkg”.

Running these installers will install a version of LaTeX onto your system, which R will then be able to call on to compile the .pdf .

Becoming familiar with LaTeX syntax (<https://tobi.oetiker.ch/lshort/lshort.pdf>) will give you a lot more options to make your R Markdown .pdf look pretty, as LaTeX commands are mostly compatible with R Markdown, though some googling is often required.

To compile a .pdf instead of a .html document, change `output:` from `html_document` to `pdf_document` .

## Common problems when compiling a .pdf

Text is running off the page

Add a `global_options` argument at the start of your .Rmd file:

```
```\r global_options, include = FALSE}
knitr::opts_chunk$set(message=FALSE,
tidy.opts=list(width.cutoff=60))
```
```

This code chunk won't be displayed in the final document due to the `include = FALSE` call and should be placed immediately after the YAML header to affect everything below that.

`tidy.opts = list(width.cutoff = 60)` defines the margin cutoff point and wraps text to the next line. Play with the value to get it right.

I lose my syntax highlighting

Use the `xelatex` engine to compile your `.pdf` :

```
- - -
author: John Doe
output: pdf_document
latex_engine: xelatex
- - -
```

By default, R markdown uses the base LaTeX engine to compile pdfs, but this may limit certain options when it comes to formatting. There are lots of other engines to play around with as well.

My page margins are too big/small

Add a `geometry` argument to the YAML header

```
- - -
title: "R Markdown Tutorial Demo"
author: "John Godlee"
date: "30/11/2016"
output: pdf_document
latex_engine: xelatex
geometry: left = 0.5cm, right = 1cm, top = 1cm, bottom = 1cm
- - -
```

`geometry` is a LaTeX command.

My plot/table/code is split over two pages

Add a page break before the dodgy element:

```
\pagebreak
```{r}
Codey codey code code
```
```

I want to change the font

Add a font argument to your header section

```
---  
title: "R Markdown Tutorial Demo"  
author: "John Godlee"  
date: "30/11/2016"  
output: pdf_document  
latex_engine: xelatex  
mainfont: Arial  
---
```

`mainfont` is a LaTeX command.

## Have a go yourself

At this point, if you haven't been following through already, have a go at converting the tutorial R script ( `RMarkdown_Tutorial.R` ) into a `.Rmd` document using the information above as a guide.

Remember that a good R markdown document should provide a reproducible log of your code, properly commented, with subtitles, comments and code relevant output so the reader knows what is going on.

## R Notebooks

RMarkdown outputs to a non-interactive file format like `.html` or `.pdf`. When presenting your code, this means you have to make a choice, do you want interactive but messy looking code ( `.Rmd` ) or non-interactive but neat looking code ( `.html` , `.pdf` )? R notebooks provide a file format that combines the interactivity of a `.Rmd` file with the attractiveness of `.html` output.

R notebooks output to the imaginatively named `.nb.html` format. `.nb.html` files can be loaded into a web browser to see the output, or loaded into a code editor like RStudio to see the code. You are able to interactively select which code chunks to hide or show code chunks.

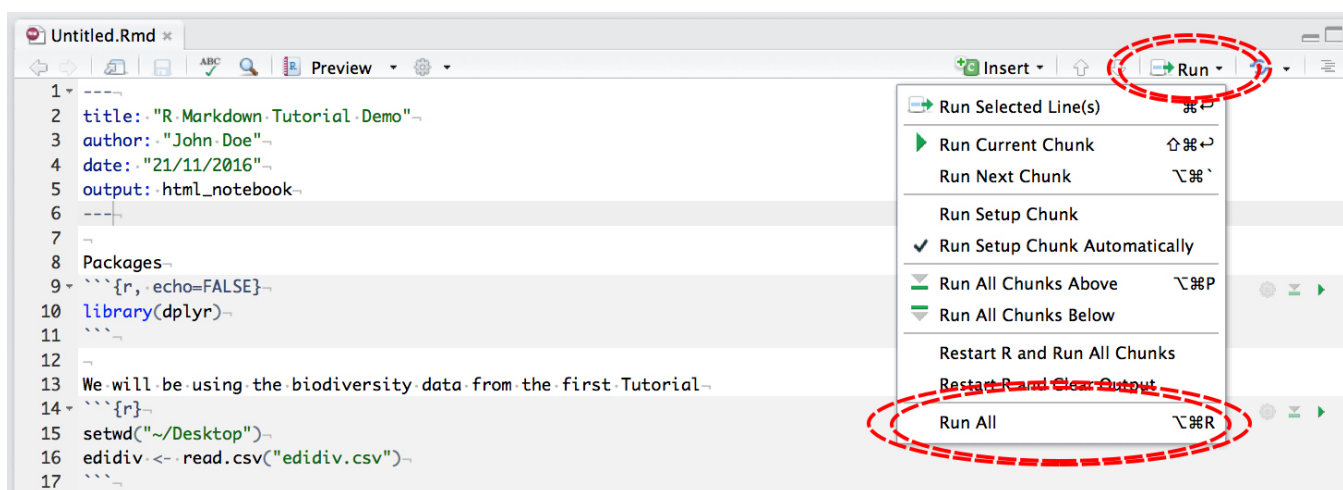
Notebooks use the same syntax as `.Rmd` files so it is easy to copy and paste the script from a `.Rmd` into a Notebook. To create a new R Notebook file, select `File -> New File -> R Notebook`. Create a notebook from your newly created `.Rmd` file by copying and pasting the script. If you choose to copy and paste the

script, make sure that under your YAML header, output: `html_notebook` instead of output: `html_document`.

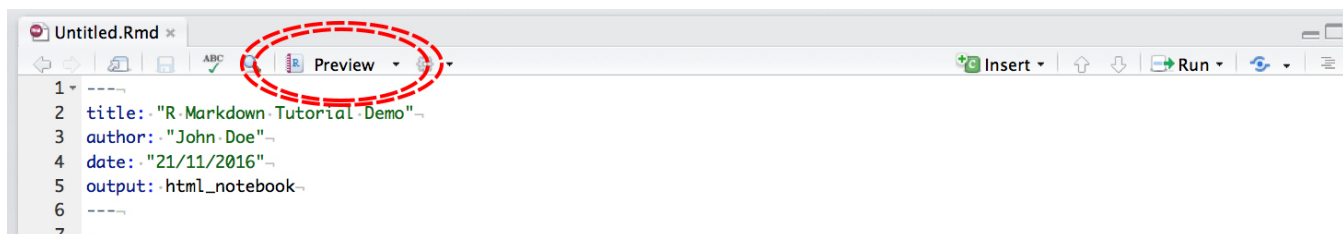
Alternatively, to turn any existing `.Rmd` file into an R notebook, add `html_notebook: default` under the output: argument in the YAML header. It's okay if you have more than one output type. For example, this code would give you a pdf and an R notebook.

```
---
title: "R Markdown Tutorial Demo"
author: "John Godlee"
date: "30/11/2016"
output:
pdf_document: default
latex_engine: xelatex
mainfont: Arial
html_notebook: default
---
```

To output to `.nb.html`, first make sure all your code chunks have been run:



then click *Preview*:



Notice that with R Notebooks you can still output to `.html` or `.pdf`, the same as a `.Rmd` file.

R notebooks have only been around for about a couple of years so they're not perfect yet, but may replace R markdown in the future for many applications.

# Difference between RMarkdown and RNotebooks

## Executing commands 1 line at a time

The first difference between R Markdown and R Notebooks is in the execution of chunks. For R Markdown, when a chunk is executed, all the code is sent to the console at once. But in an R Notebook, only one line at a time is sent. This allows execution to stop if a line raises an error in R Notebooks.

## Preview in R Notebooks vs Knit in R Markdown

R Markdown documents are 'knitted', while R Notebooks are 'previewed'.

Although the notebook preview looks similar to the knitted markdown document, the notebook preview does not execute any code chunks, but only shows you a rendered copy of the Markdown output of your document along with the most recent chunk output. The preview is also generated automatically whenever the notebook is saved. This would be especially useful if we have the preview showing in the Viewer window next to the console. **This means that in R Notebooks, we are able to visually assess the output as we develop the document without having to knit the whole document again.**

For example, with the following code chunk example (from the `RMarkdown_Tutorial.R` practice script), we are creating a table of species richness for each taxonomic group.

```
```{r}
richness <-
  edidiv %>%
  group_by(taxonGroup) %>%
  summarise(Species_richness = n_distinct(taxonName))
```
```

To bring up the table output, we can add `richness`, `pander(richness)`, `kable(richness)` to the end of that code chunk. If we had initially forgotten to add in either one of those functions, the table would not have been produced in both the knitted markdown document and the notebook preview. Imagine that we are now editing the R Markdown document / R Notebook document to include this function to bring up the table in the outputted document.

For RMarkdown: we would type in `pander(richness)`, run that specific code chunk, and then have to click the Knit button in the taskbar to knit the whole document again.



For R Notebooks, we type in `pander(richness)` , run that specific code chunk, and save the document, and the preview in the Viewer window would be updated on its own - there is no need to click the Preview button in the taskbar and run the code for the whole document.

**Note: R Markdown Notebooks are only available in RStudio 1.0 or higher.**

## Bonus task!

Either in a small group or on your own, convert one of the three demo R scripts into a well commented and easy to follow R Markdown document, or R Markdown Notebook. The files ( `RMarkdown_Demo_1.R` , `RMarkdown_Demo_2.R` , `RMarkdown_Demo_3.R` ) can be found in the repo you downloaded earlier (<https://github.com/ourcodingclub/CC-2-RMarkdown>).

## Tutorial Outcomes:

1. You are familiar with the `Markdown` syntax and code chunk rules.
2. You can include figures and tables in your `Markdown` reports.
3. You can create `RMarkdown` files and export them to `pdf` or `html` files.

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You can contact us with any questions on  
[ourcodingclub@gmail.com](mailto:ourcodingclub@gmail.com)  
(mailto:ourcodingclub@gmail.com?  
Subject=Tutorial%20question)

## Related tutorials:

- Getting Started with R Markdown (<http://ourcodingclub.github.io/2016/11/24/rmarkdown-1.html>)

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