# Reproducible Research

## An Introduction to knitr

Sahir Rai Bhatnagar[1]

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[1] https://github.com/sahirbhatnagar/knitr-tutorial

# Acknowledgements


- Dr. Erica Moodie
- Maxime Turgeon (Windows)
- Kevin McGregor (Mac)
- Greg Voisin
- Don Knuth (TeX)
- Friedrich Leisch (Sweave)
- Yihui Xie (knitr)
- You


# Disclaimer #1

- Feel free to Ask questions
- Interrupt me often
- You don't need to raise your hand to speak

# Disclaimer #2

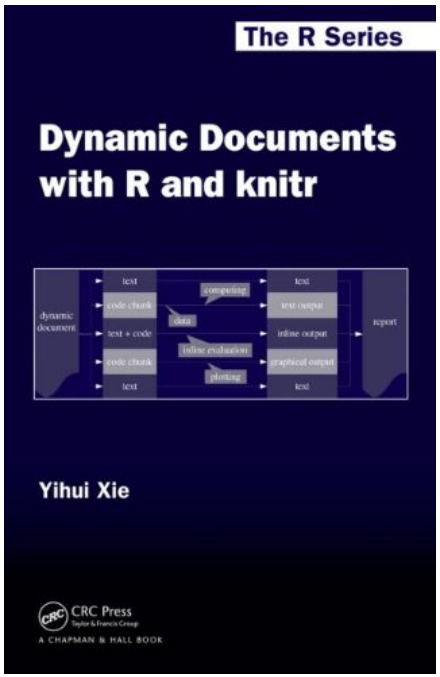


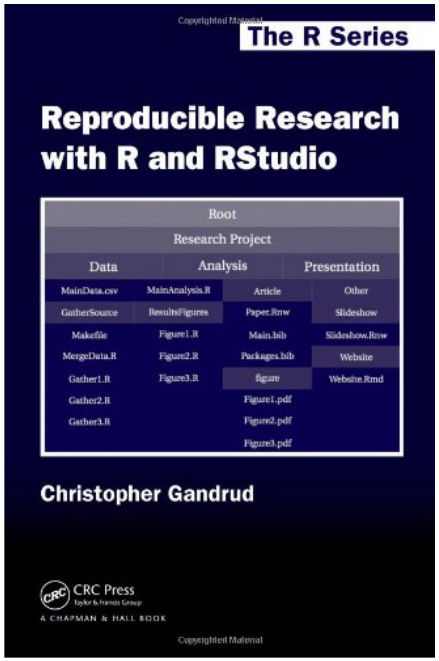


*I don't work for, nor am I an author of any of these packages. I'm just a messenger.*

# Disclaimer #3

- Material for this tutorial comes from many sources. For a complete list see: https://github.com/sahirbhatnagar/knitr-tutorial
- Alot of the content in these slides are based on these two books



# Eat Your Own Dog Food

- These slides are reproducible
- Source code: https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/slides

# Main objective for today

# What is Science Anyway?

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## According to the American Physical Society:

*Science is the systematic enterprise of gathering knowledge about the universe and organizing and condensing that knowledge into* **testable** *laws and theories. The* **success and credibility of science** *are anchored in the* **willingness** *of scientists to* **expose their ideas** *and results to* **independent testing** *and* **replication** *by other scientists*

# RR: A Minimum Standard to Verify Scientific Findings

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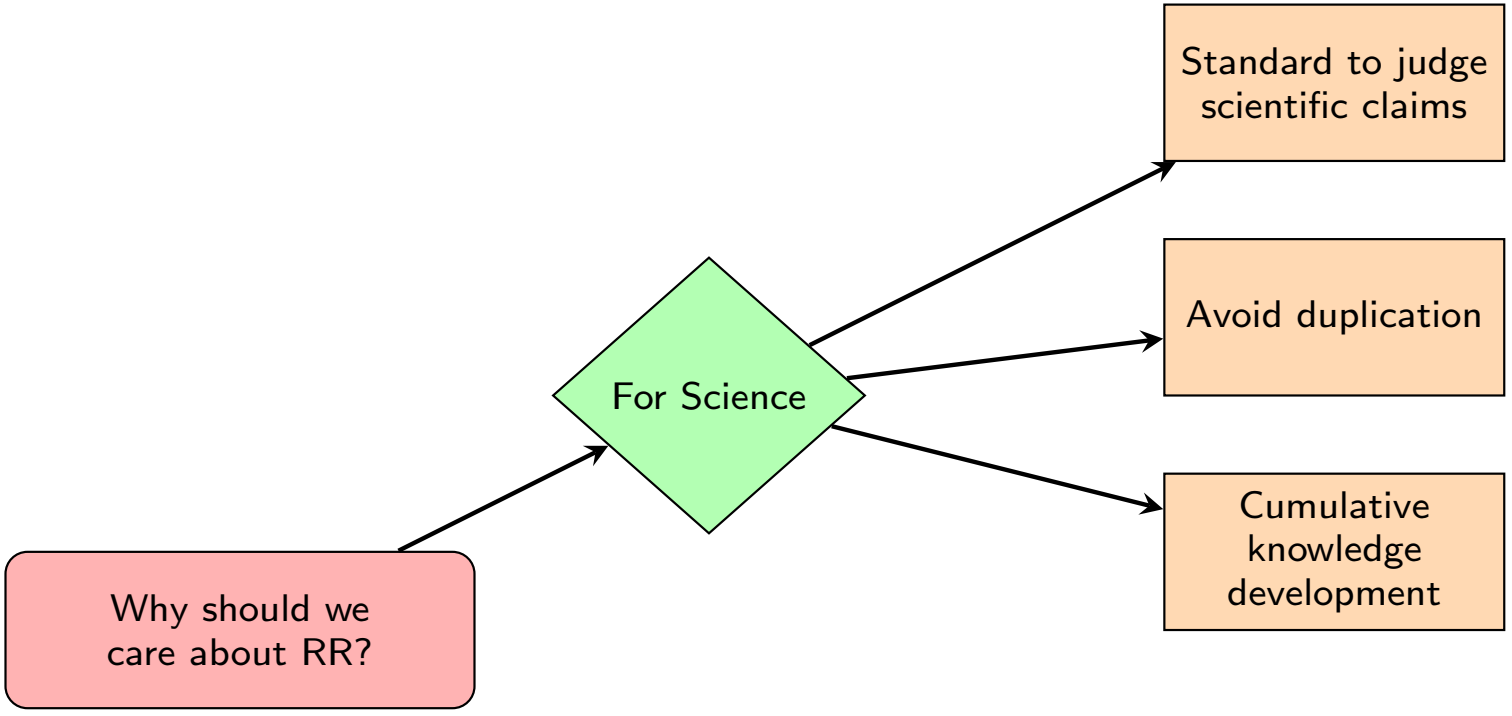
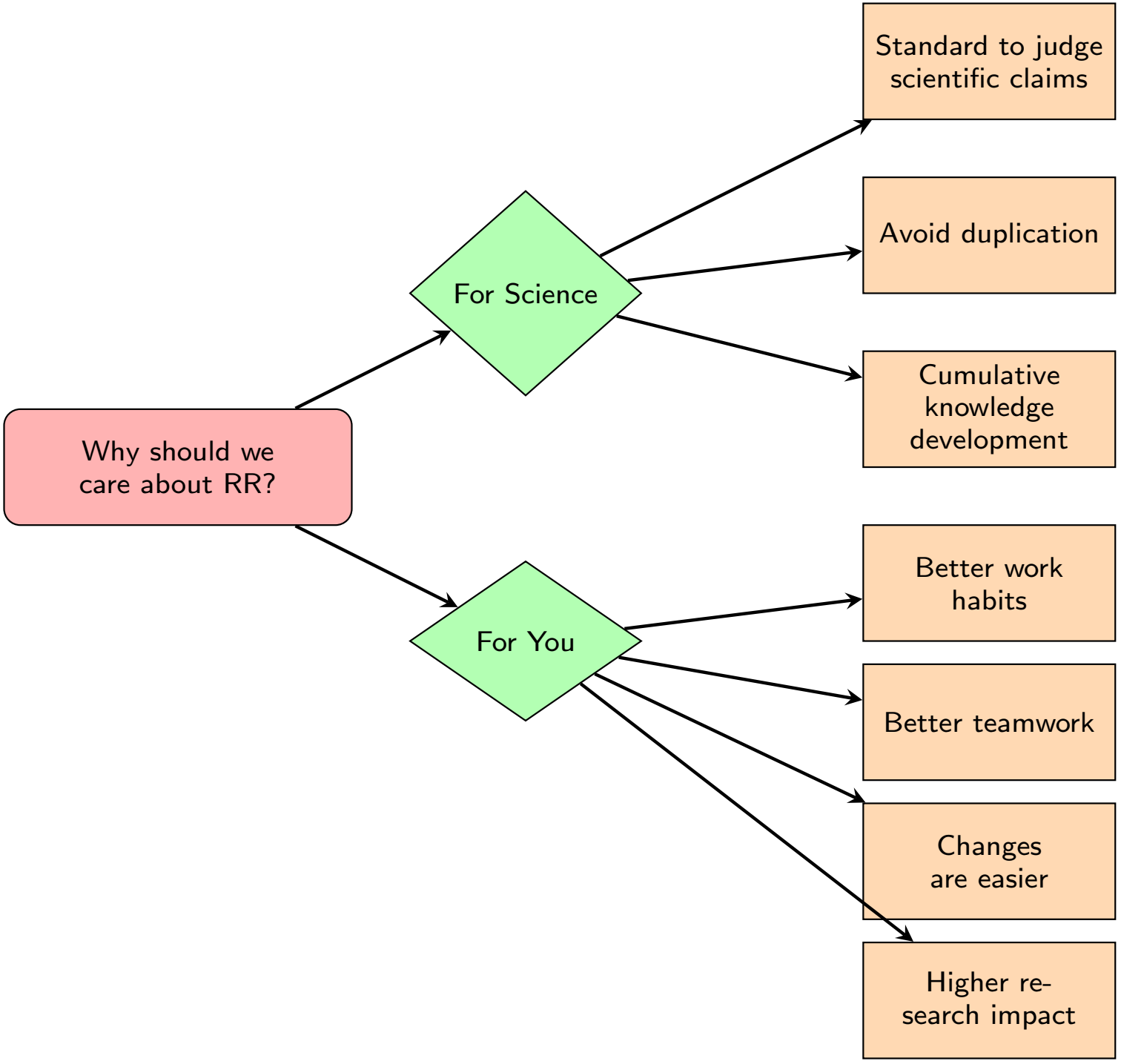
## Reproducible Research (RR) in Computational Sciences

*The data and the code used to make a finding are available and they are sufficient for an independent researcher to recreate the finding*





# A Motivating Example

*Demonstrate:* 001-motivating-example
*Survey:* https://www.surveymonkey.com/s/CDVXW3C

# Tools for Reproducible Research[2]

## Free and Open Source Software

- `RStudio`: Creating, managing, compiling documents
- LaTeX: Markup language for typesetting a document
- `R`: Statistical analysis language
- `knitr`: Integrate LaTeXand `R` code. Based on Prof. Friedrich Leisch's `Sweave`

[2] http://onepager.togaware.com/

# Comparison

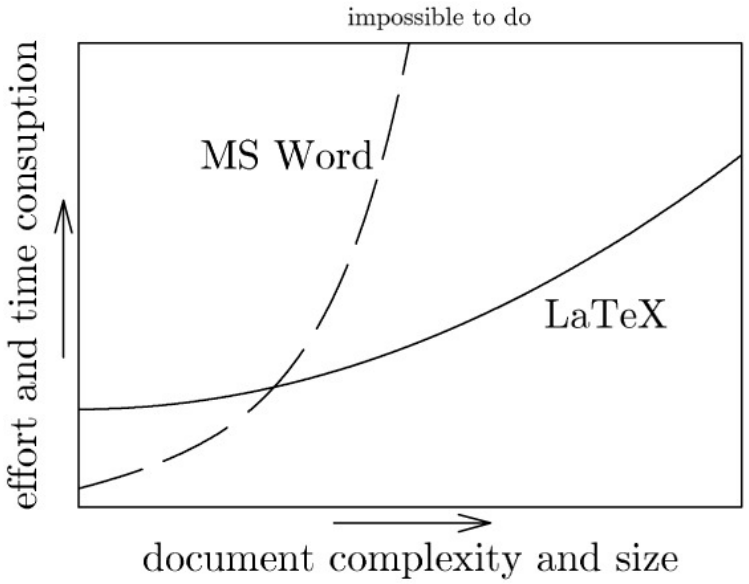



Figure 1 : Comparison

- LaTeX has a greater learning curve
- Many tasks are very tedious or impossible (most cases) to do in MS Word or Libre Office

# The Philosophy behind LaTeX

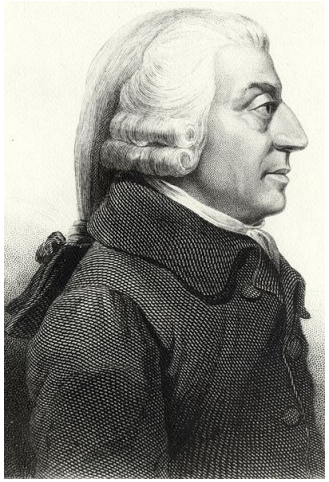


Figure 2 : Adam Smith, author of *The Wealth of Nations* (1776), in which he conceptualizes the notion of the division of labour

## Division of Labour

Composition and logical structuring of text is the author's specific contribution to the production of a printed text. Matters such as the choice of the font family, should section headings be in bold face or small capitals? Should they be flush left or centered? Should the text be justified or not? Should the notes appear at the foot of the page or at the end? Should the text be set in one column or two? and so on, is the typesetter's business

# The Genius Behind LaTeX

Figure 3 : The TeX project was started in 1978 by Donald Knuth (Stanford). He planned for 6 months, but it took him nearly 10 years to complete. Coined the term "Literate programming": mixture of code and text segments that are "human" readable. Recipient of the Turing Award (1974) and the Kyoto Prize (1996).

# Integrated Development Environment (IDE)

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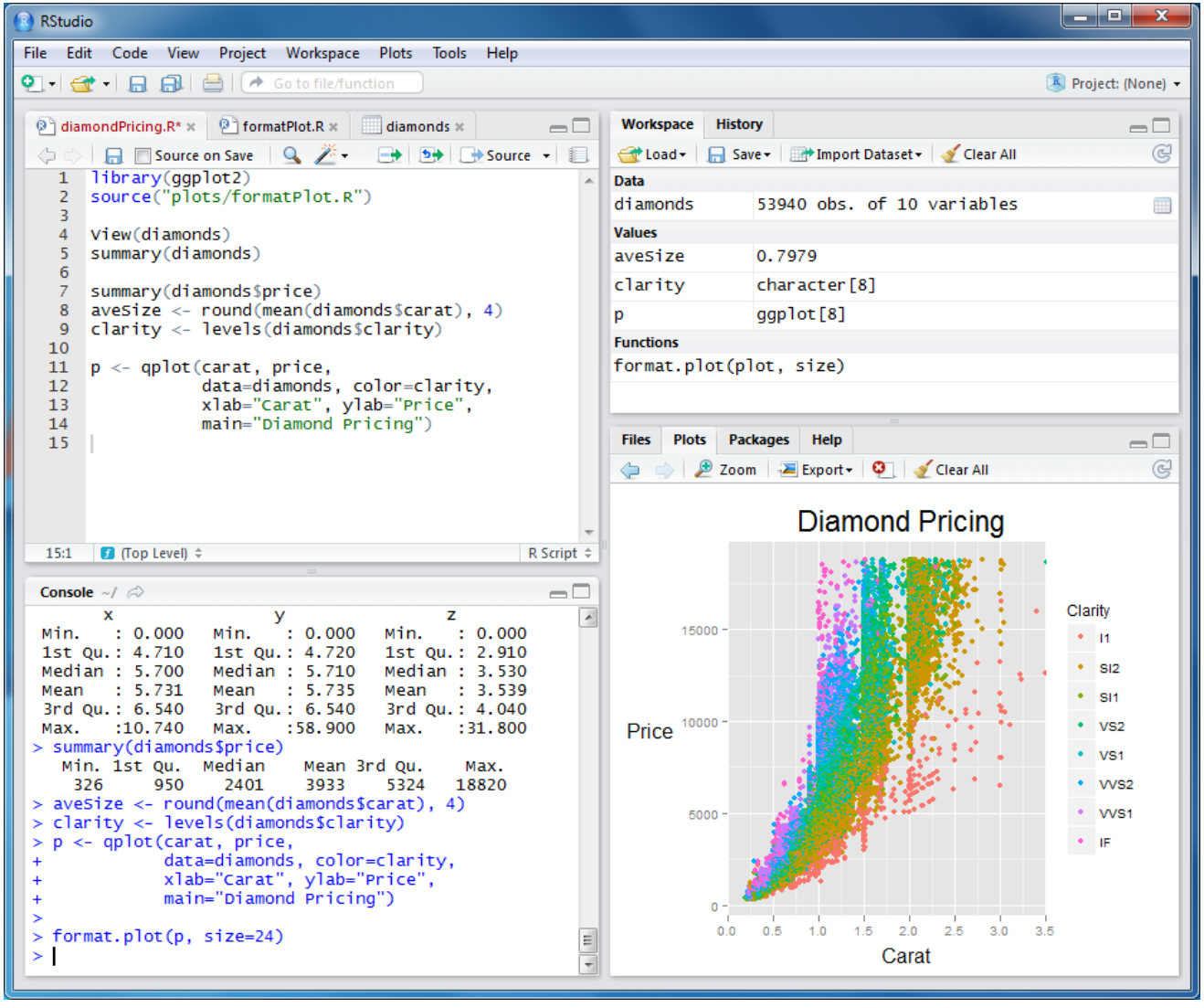
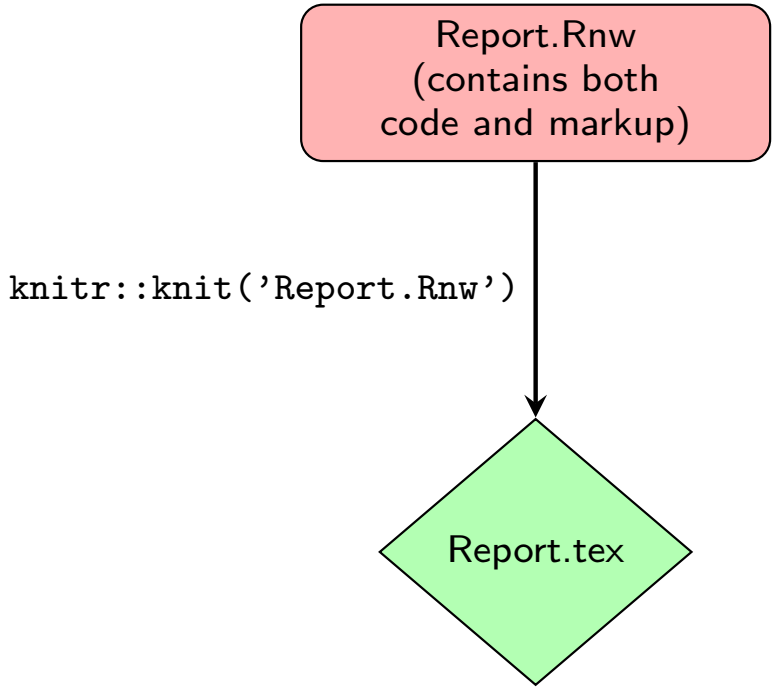



*Demonstrate:* Explore `RStudio`

# What knitr does



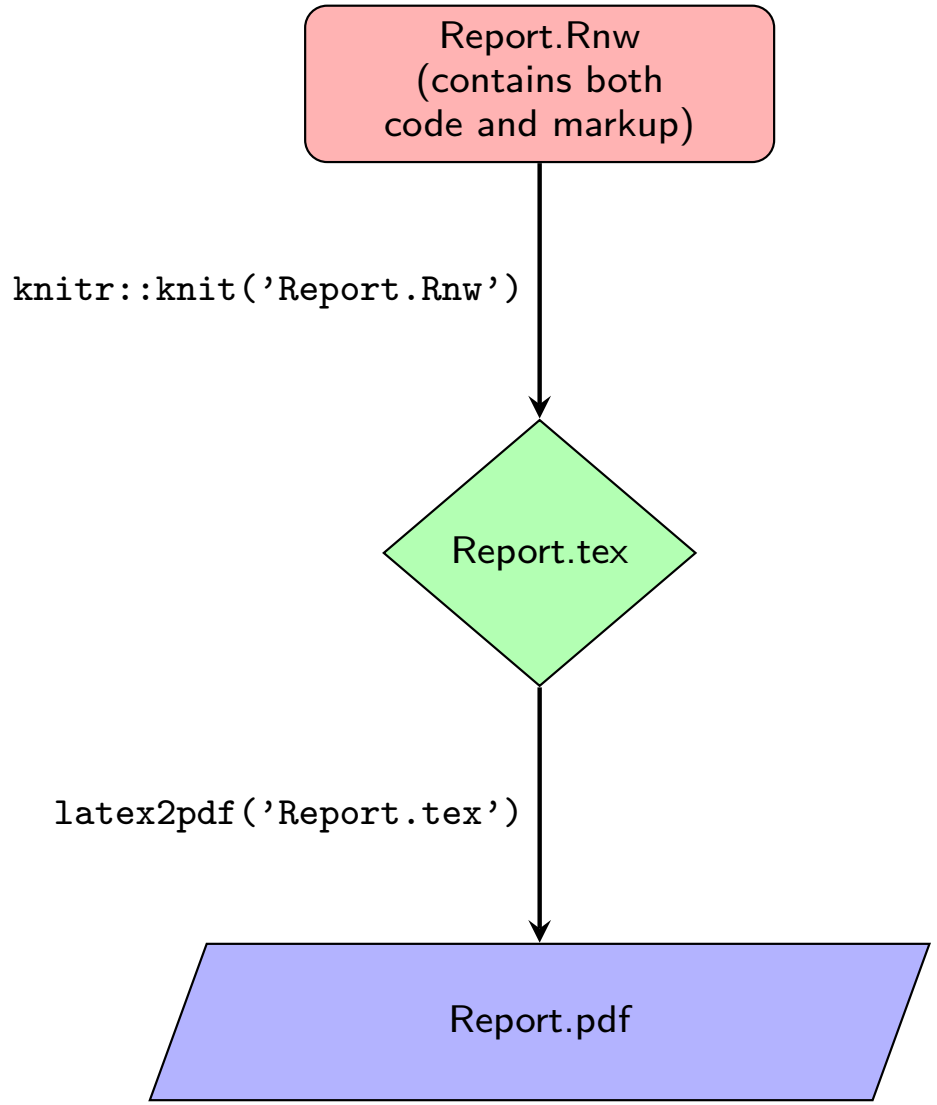
LaTeX example:



# What knitr does



LaTeX example:

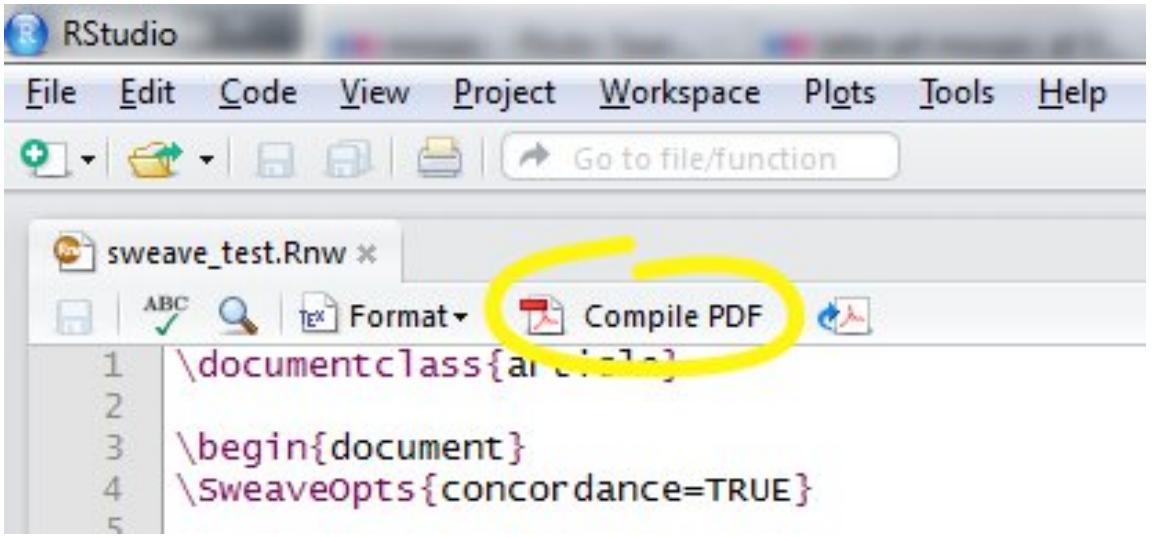


# Compiling a `.Rnw` document

The two steps on previous slide can be executed in one command:

```
knitr::knit2pdf()
```

or in RStudio:



# Incorporating R code

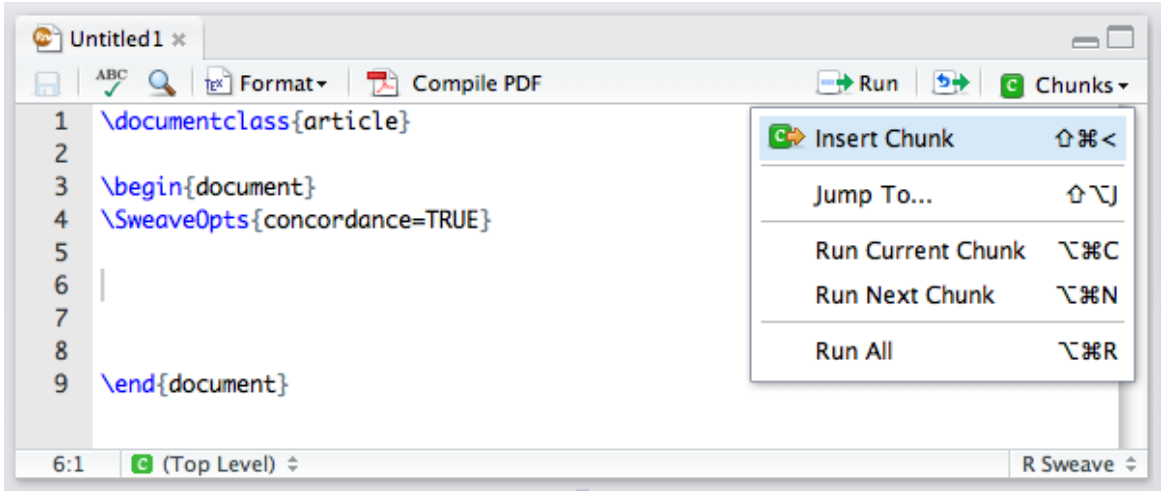
- Insert R code in a **Code Chunk** starting with

  <<  >>=

  and ending with

  @

In RStudio:



# Example 1

```
<<example-code-chunk-name, echo=TRUE>>=
library(magrittr)
rnorm(50) %>% mean
@
```

produces

```
library(magrittr)
rnorm(50) %>% mean

## [1] 0.031
```

# Example 2

```
<<example-code-chunk-name2, echo=TRUE, tidy=TRUE>>=
for(i in 1:5){ (i+3) %>% print}
@
```

produces

```
for (i in 1:5) {
    (i + 3) %>% print
}
```

```
## [1] 4
## [1] 5
## [1] 6
## [1] 7
## [1] 8
```

# Example 2.2

```
<<example-code-chunk-name3, echo=FALSE>>=
for(i in 1:5){ (i+3) %>% print}
@
```

produces

```
## [1] 4
## [1] 5
## [1] 6
## [1] 7
## [1] 8
```

# Example 2.3

```
<<example-code-chunk-name4, echo=FALSE, eval=FALSE>>=
for(i in 1:5){ (i+3) %>% print}
@
```

produces

*Demonstrate:* Try it yourself

# R output within the text

- Include R output within the text
- We can do that with "S-expressions" using the command \Sexpr{...}

**Example:**

The iris dataset has \Sexpr{nrow(iris)} rows and \Sexpr{ncol(iris)} columns

produces

The iris dataset has 150 rows and 5 columns

# Include a Figure



```
<<fig.ex, fig.cap='Linear Regression',fig.height=3,fig.width=3>>=
plot(mtcars[ , c('disp','mpg')])
lm(mpg ~ disp , data = mtcars) %>%
abline(lwd=2)
@
```

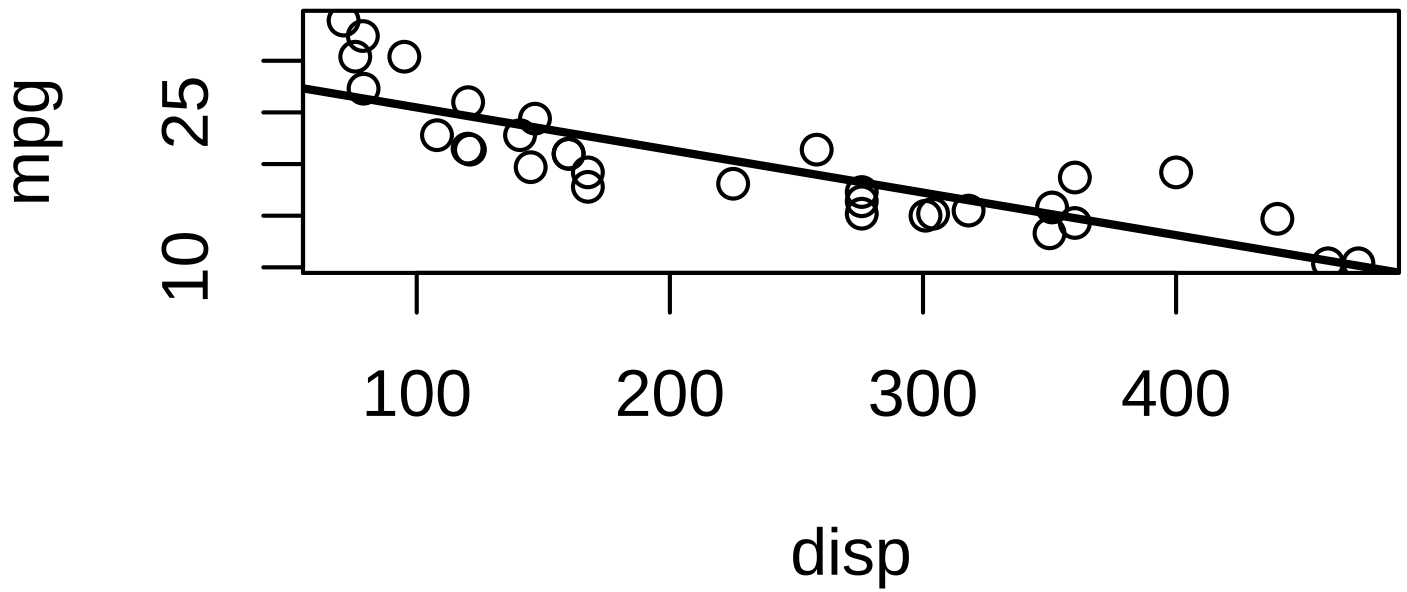



Figure 4 : Linear regression

# Include a Table

```
<<table.ex, results='asis'>>=
library(xtable)
iris[1:5,1:5] %>%
xtable(caption='Sample of Iris data') %>%
print(include.rownames=FALSE)
@
```

| Sepal.Length | Sepal.Width | Petal.Length | Petal.Width | Species |
|---|---|---|---|---|
| 5.10 | 3.50 | 1.40 | 0.20 | setosa |
| 4.90 | 3.00 | 1.40 | 0.20 | setosa |
| 4.70 | 3.20 | 1.30 | 0.20 | setosa |
| 4.60 | 3.10 | 1.50 | 0.20 | setosa |
| 5.00 | 3.60 | 1.40 | 0.20 | setosa |

Table 1 : Sample of Iris data

# Minimum Working Example

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/002-minimum-working-example

# Extracting output from Regression Models

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/003-model-output

# Figures

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/004-figures

# Beamer Presentations

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/005-beamer-presentation

# Changing one Parameter in an Analysis

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/006-sensitivity-analysis-one-parameter

# Changing Many Parameters in an Analysis

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/007-sensitivity-analysis-many-parameters

# Large Documents

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/008-large-documents

# HTML Reports

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/009-rmarkdown

# HTML Presentations

https://github.com/sahirbhatnagar/knitr-tutorial/tree/master/010-rmarkdown-presentation

# Opinion: Reproducible research can still be wrong: Adopting a prevention approach

**Jeffrey T. Leek**[a,1] **and Roger D. Peng**[b]
[a]*Associate Professor of Biostatistics and Oncology and* [b]*Associate Professor of Biostatistics, Johns Hopkins University, Baltimore, MD*

computational tools such as knitr, iPython notebook, LONI, and Galaxy (8) have simplified the process of distributing reproducible data analyses.

# Is the juice worth the squeeze?