

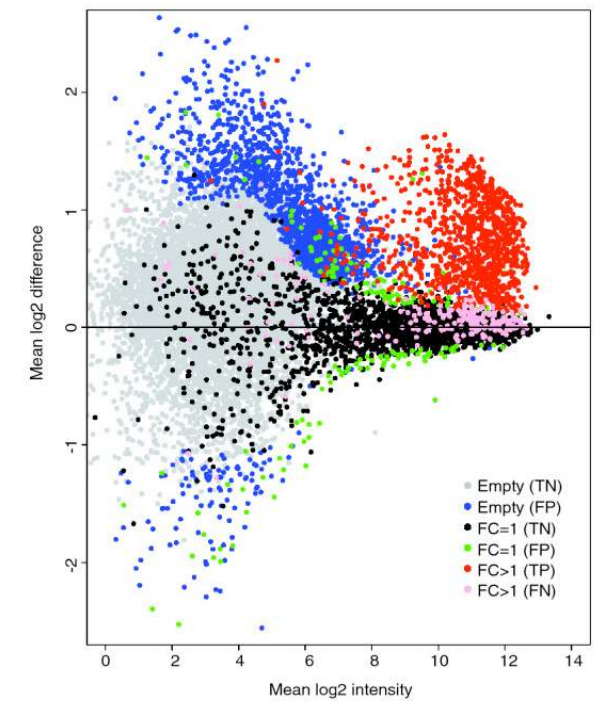
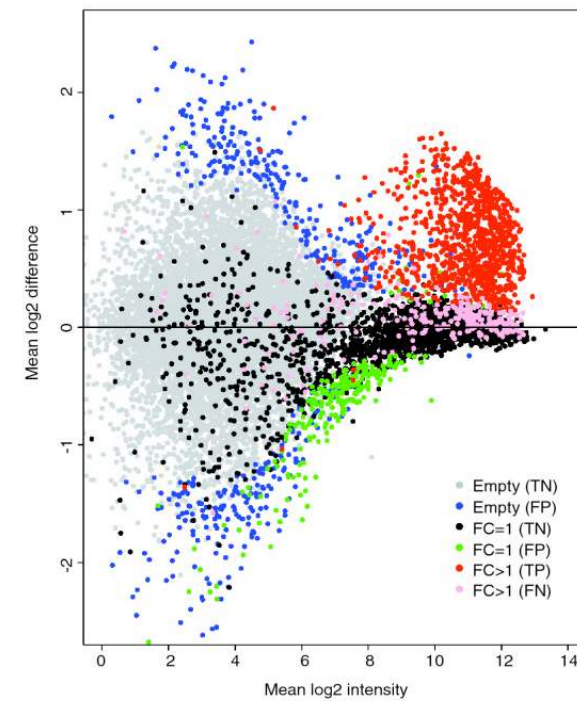
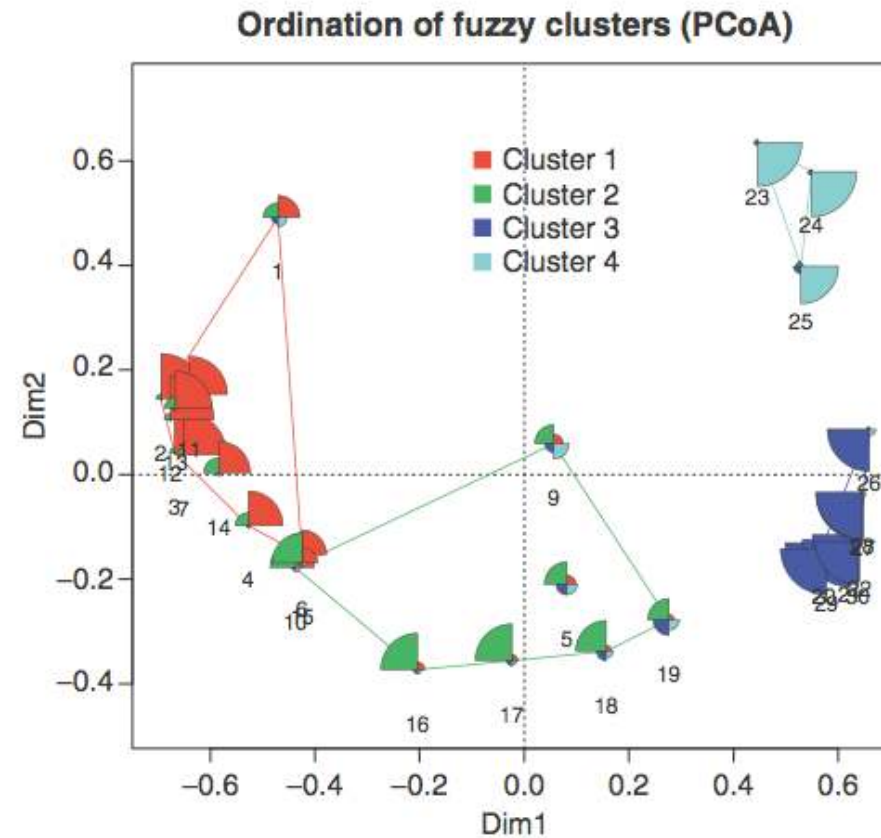
An Introduction to R

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What is R?

A free software environment for statistical computing and graphics.



Why is R useful?

- Data management and manipulation
- Well established system of packages and documentation
- Support for rich statistical simulation and modeling
- High-level interpreted language to prototype new computational methods
- Active development and dedicated community
- Cutting-edge graphical data visualization
- Free!

Where to learn more about R

- The R Project Homepage: <http://www.r-project.org>
- Quick R Homepage: <http://www.statmethods.net>
- Bioconductor: <http://www.bioconductor.org>
- An Introduction to R (long!): <http://cran.r-project.org/doc/manuals/R-intro.html>
- Google - there are tons of tutorials, guides, demos, packages and more

R for Biologists

- Bioconductor (<http://bioconductor.org>)
 - 1473 packages (17-1-2018):
 - Variant detection: coding changes, PolyPhen database
 - Annotation: pathway analysis, access GO, KEGG, NCBI and many others
 - High-throughput assays: flow cytometry, mass spec
 - Transcription factor binding detection
- Ecology (see: <http://cran.r-project.org/web/views/Environmetrics.html>)
 - Ordination
 - Cluster Analysis
 - Ecological Theory
 - Population Dynamics
 - Spatial Data Analysis
- Phylogenetics and Evolution (see: <http://cran.r-project.org/web/views/Phylogenetics.html>)
 - Ancestral State Reconstruction
 - Phylogenetic Inference
 - Trait Evolution

Obtaining R

- Ubuntu

```
sudo apt-get update
```

```
sudo apt-get install r-base r-base dev
```

... or use the Ubuntu package manager

- Install directly from CRAN (The **C**omprehensive **R** **A**rchive **N**etwork)

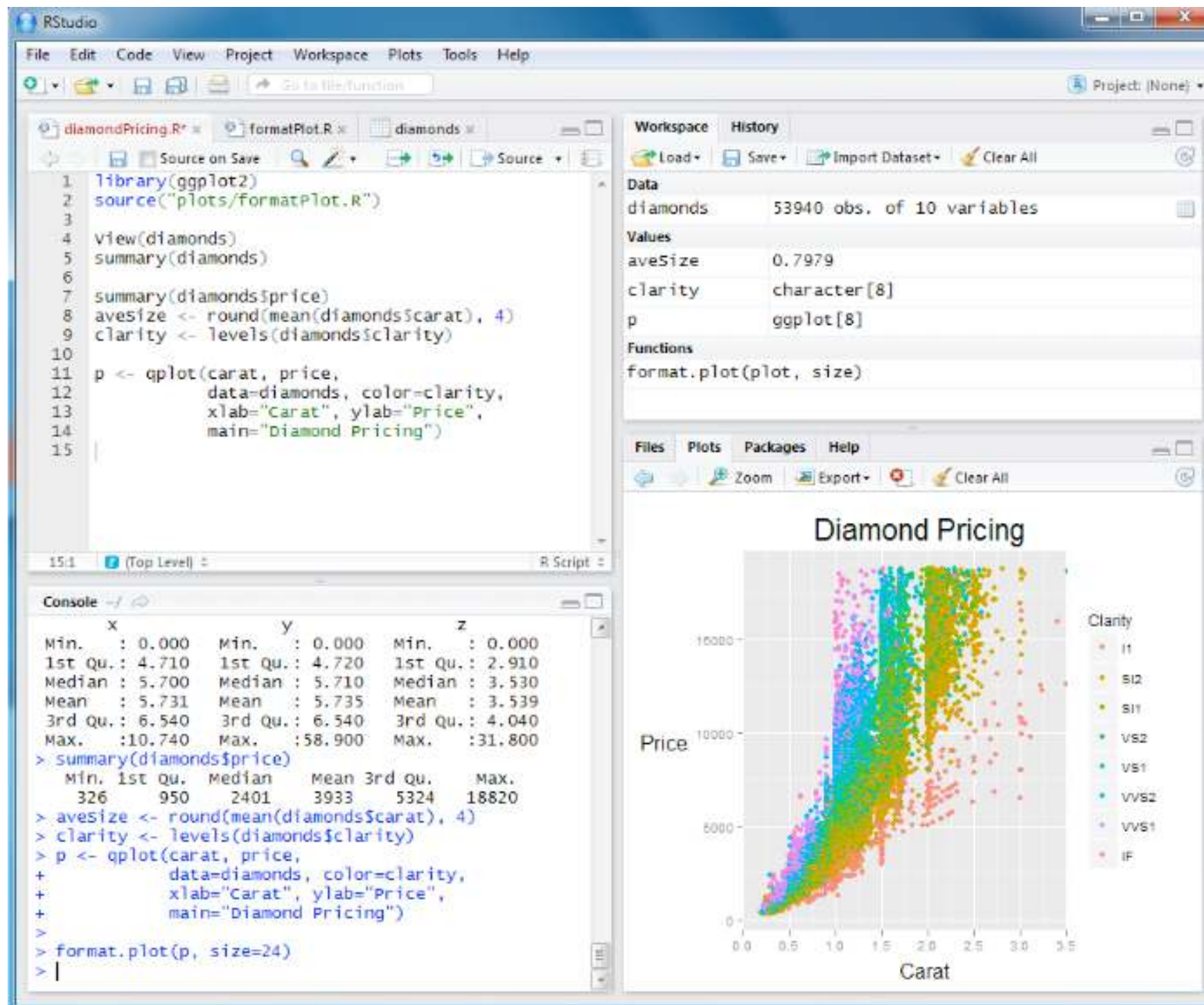
- <http://cran.r-project.org/bin/macosx/>



Running R

- Install a R Integrated Development Environment (IDE)
 - RStudio: <http://www.rstudio.com>
 - R Commander: <http://socserv.mcmaster.ca/jfox/Misc/Rcmdr/>
 - Both projects can make working with R much easier, particularly for a new R user
 - Both IDE's run on Windows, Mac or Linux OS
- Or from the command line, type R

R Studio



Basic R functionality

Calculator

- `+`, `-`, `/`, `*`, `^`, `log()`, `exp()`, `sqrt()`,
`abs()`, `cos()`, `sin()`, `tan()`, ...

```
(4+5^2)/3.14  
[1] 9.235669
```

Set Variables / Vectors

```
y=13.4
```

```
>y
```

```
[1] 13.4
```

```
y=c(1,2,3,4,5)
```

```
>y
```

```
[1] 1 2 3 4 5
```

Sequences

```
y=rep(2,10)
```

```
[1] 2 2 2 2 2 2 2 2 2 2
```

```
y=2:8
```

```
[1] 2 3 4 5 6 7 8
```

Statistics

```
t.test(7:34, 5:29)
```

```
t = 1.6348, df = 50.999, p-value = 0.1082
```

```
alternative hypothesis: true difference in means is not  
equal to 0
```

```
95 percent confidence interval:
```

```
-0.797982  7.797982
```

```
sample estimates:
```

```
mean of x mean of y
```

```
20.5      17.0
```

Manipulation I

`n=c(3, 7, 12, 50, 103)`

`n[4]` [1] 50

`n[-2]` [1] 3 12 50 103

`n[1:3]` [1] 3 7 12

`n[c(1,3,5)]` [1] 3 12 103

`n[n<50]` [1] 3 7 12

`n[n>8 & n!=50]` [1] 12 103

Manipulation II

```
n=c(3, 7, 12, 50, 103)
```

```
n+1
```

```
[1] 4 8 13 51 104
```

```
sum(n)
```

```
[1] 175
```

```
mean(n)
```

```
[1] 35
```

```
var(n)
```

```
[1] 1796.5
```

```
min(n)
```

```
[1] 3
```

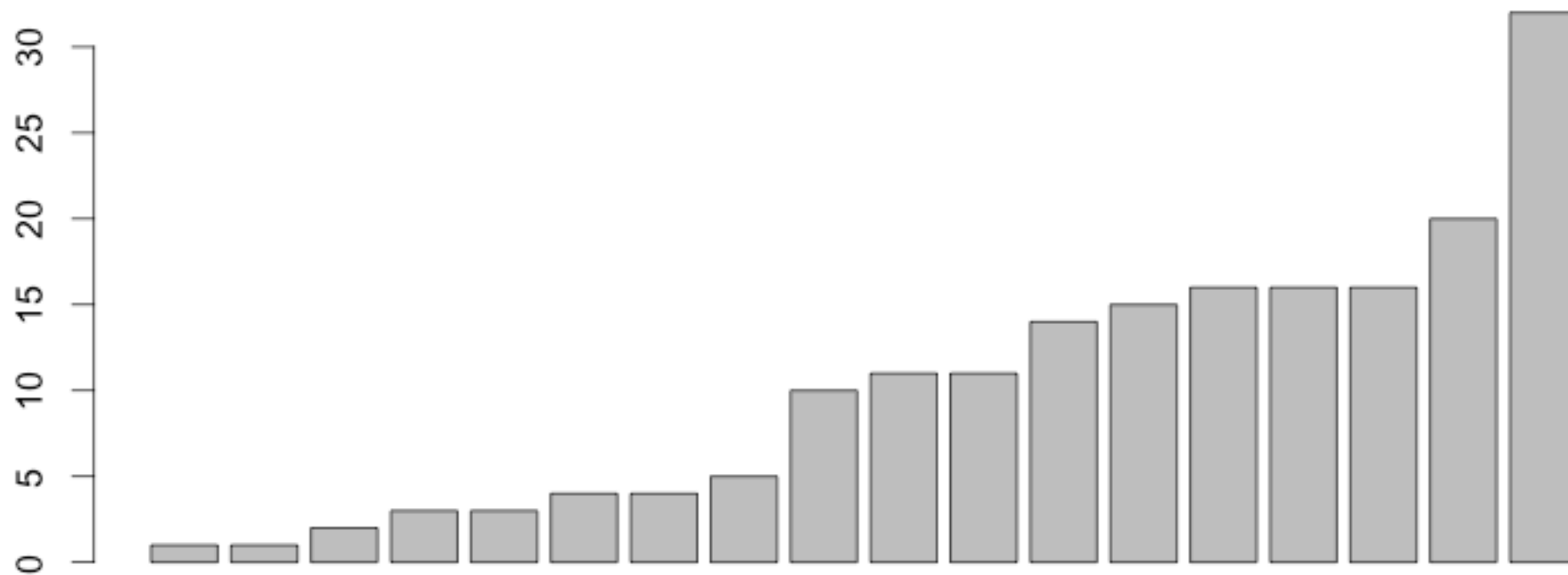
```
max(n)
```

```
[1] 103
```

Basic Visualization I

`y=c(1,1,2,3,3,4,4,5,10,11,11,14,15,16,16,16,20,32)`

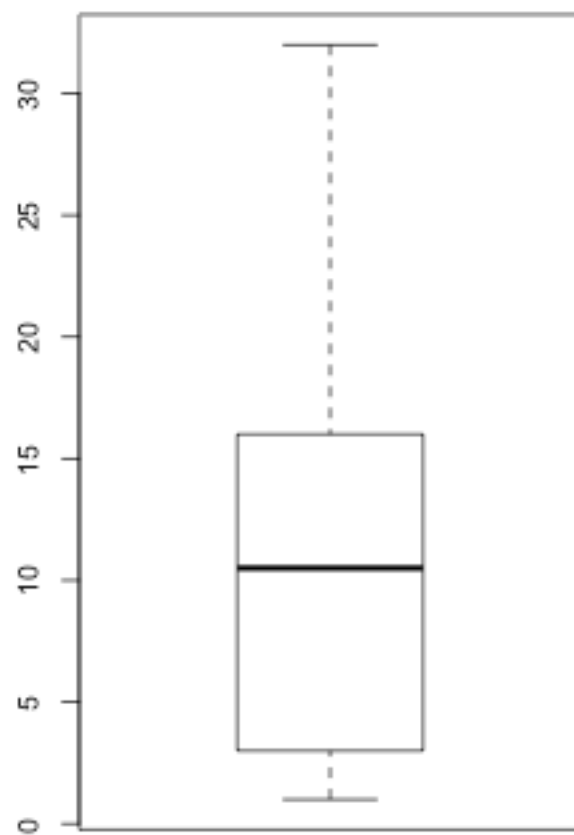
`barplot(y)`



Basic Visualization II

```
y=c(1,1,2,3,3,4,4,5,10,11,11,14,15,16,16,16,20,32)
```

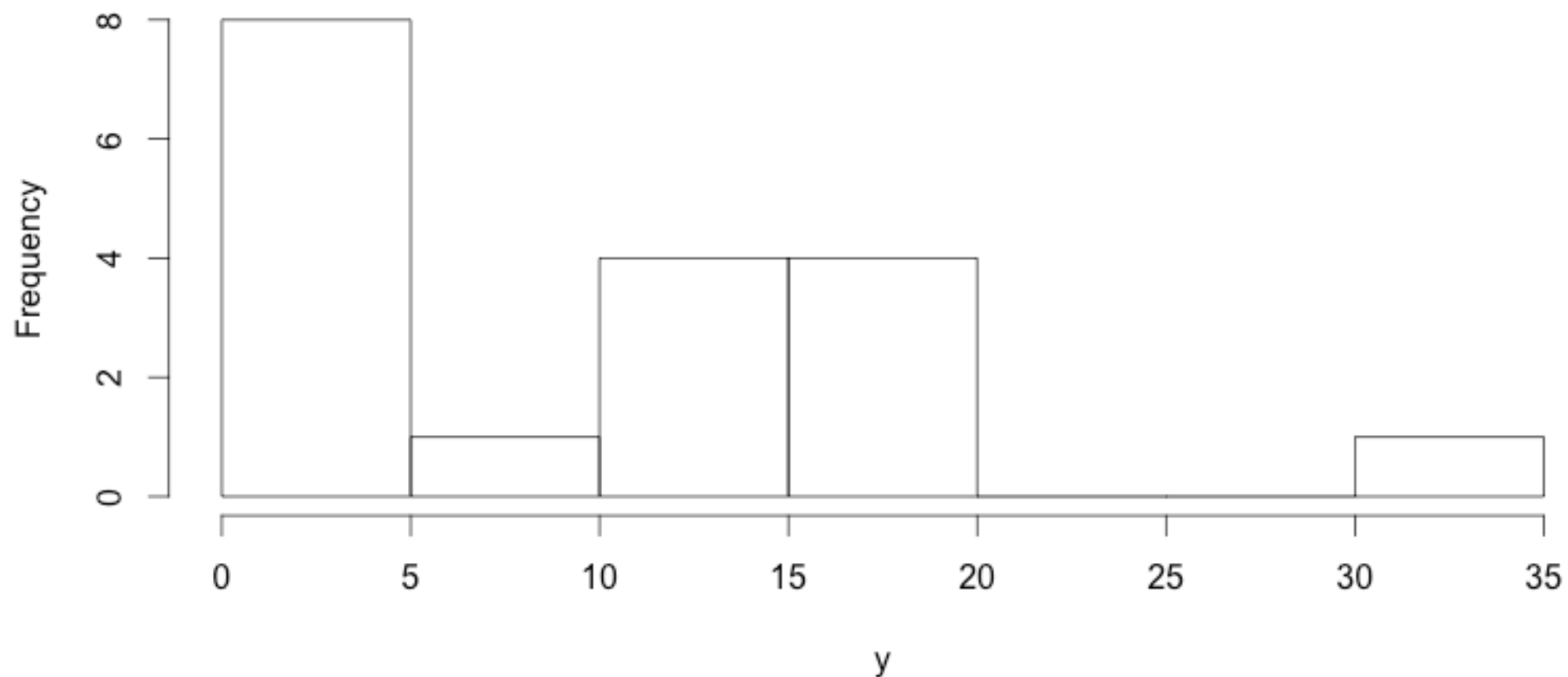
```
boxplot(y)
```



Basic Visualization III

`y=c(1,1,2,3,3,4,4,5,10,11,11,14,15,16,16,16,20,32)`

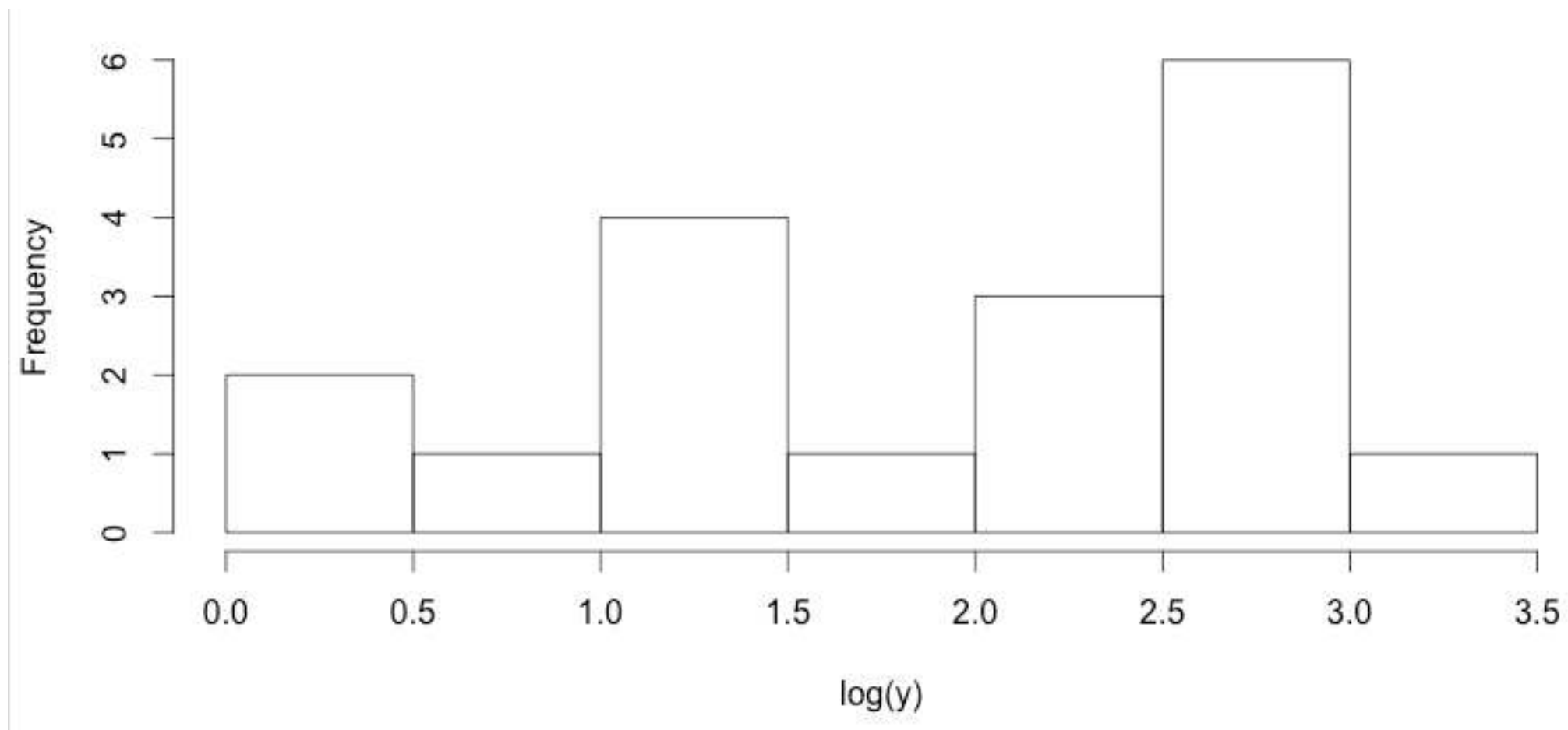
`hist(y)`



Basic Visualization III.i

`y=c(1,1,2,3,3,4,4,5,10,11,11,14,15,16,16,16,20,32)`

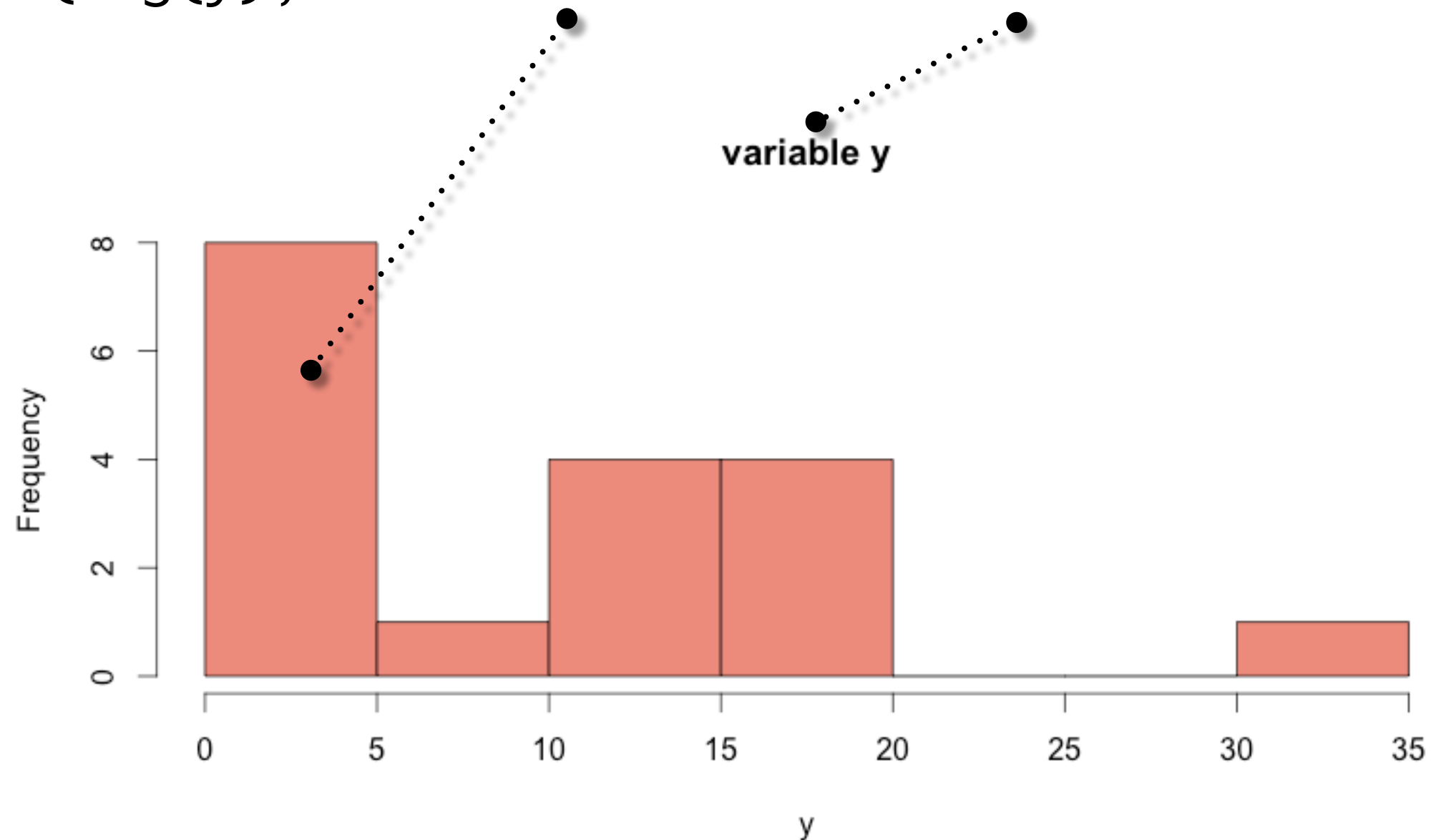
`hist(log(y))`



Basic Visualization III.ii

`y=c(1,1,2,3,3,4,4,5,10,11,11,14,15,16,16,16,20,32)`

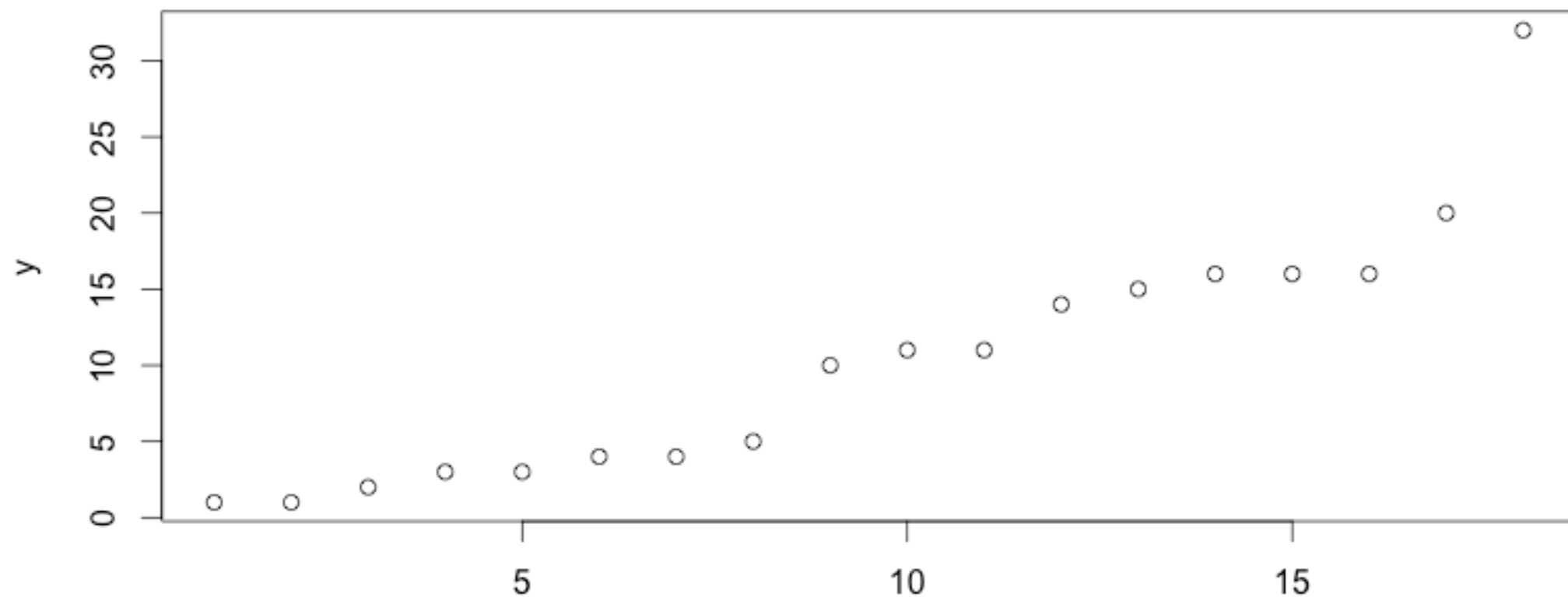
`hist(log(y),`



Basic Visualization IV

$y=(1,1,2,3,3,4,4,5,10,11,11,14,15,16,16,16,20,32)$

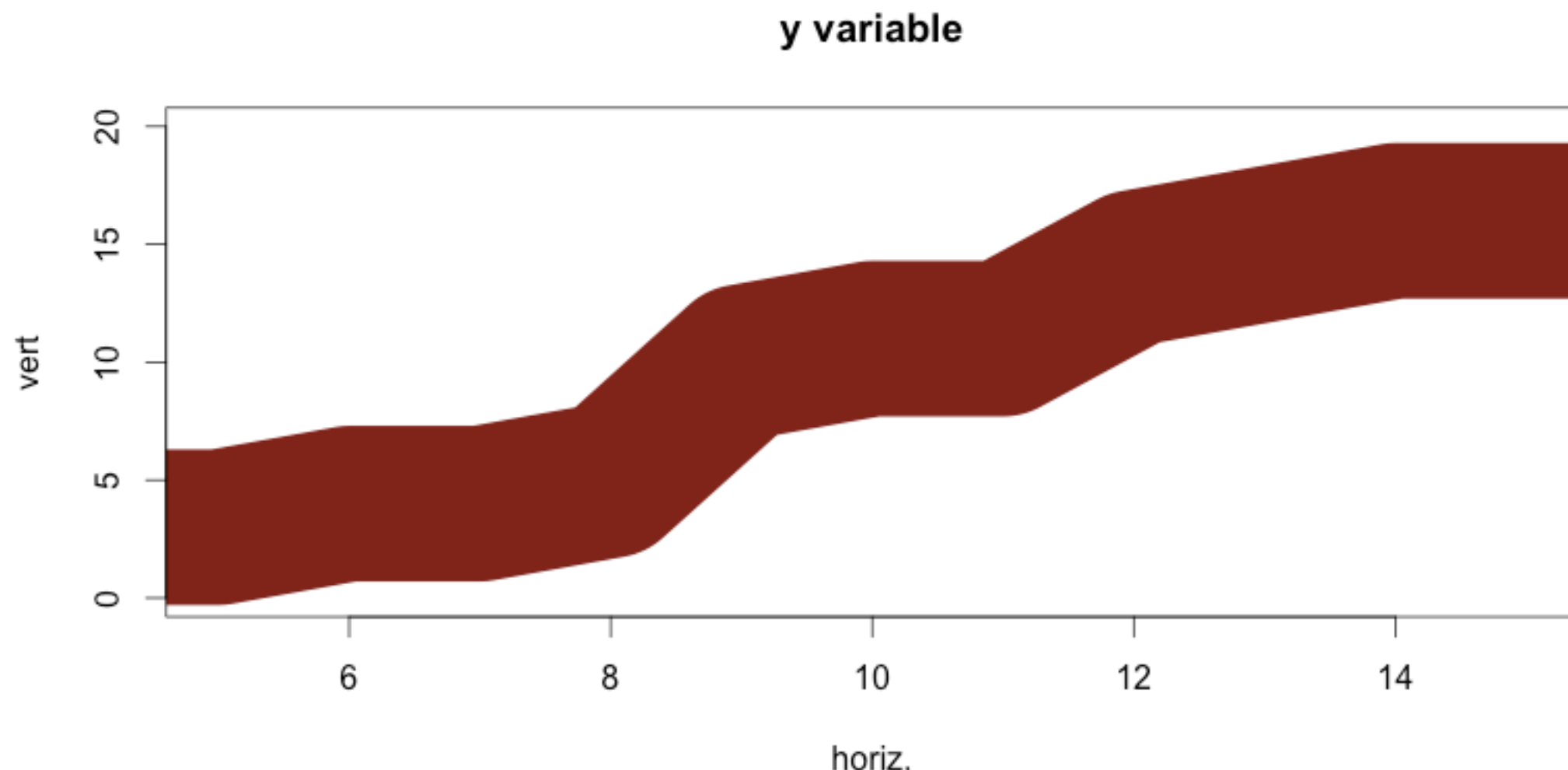
`plot(y)`



Basic Visualization IV.ii

```
y=(1,1,2,3,3,4,4,5,10,11,11,14,15,16,16,16,20,32)
```

```
plot(y, type="l", col="dark red", lwd=100, main="y  
variable", ylim=c(0,20), xlim=c(5,15), ylab="vert",  
xlab="horiz.")
```



Help

- Do you need to remember all of the variables?
- ? is your friend
- ?plot

plot {graphics}

Generic X-Y Plotting

Description

Generic function for plotting of **R** objects. For more details about the graphical parameter arguments, see [par](#).

For simple scatter plots, [plot.default](#) will be used. However, there are `plot` methods for many **R** objects, including [functions](#), [data.frames](#), [density](#) objects, etc. Use `methods(plot)` and the documentation for these.

Usage

```
plot(x, y, ...)
```

R Documentation

`type`

what type of plot should be drawn. Possible types are

- "p" for **p**oints,
- "l" for **l**ines,
- "b" for **b**oth,
- "c" for the **l**ines part alone of "b",
- "o" for both '**o**verplotted',
- "h" for '**h**istogram' like (or 'high-density') vertical lines,
- "s" for stair **s**teps,
- "S" for other **s**teps, see 'Details' below,
- "n" for no plotting.

Data Frames

- A data.frame is essentially a table

- columns can be mixes types

- numeric, text strings

- rows must be same type

	clostridia	proteobacteria	bacteroides
01_healthy	22	54	245
02_healthy	26	65	265
03_healthy	34	66	262
01_sick	32	32	116
02_sick	12	24	101
03_sick	9	18	87

`data.frame[-1,-2]`

	clostridia	bacteroides
02_healthy	26	265
03_healthy	34	262
01_sick	32	116
02_sick	12	101
03_sick	9	87

Data Frame Manipulations

	clostridia	proteobacteria	bacteroides
01_healthy	22	54	245
02_healthy	26	65	265
03_healthy	34	66	262
01_sick	32	32	116
02_sick	12	24	101
03_sick	9	18	87

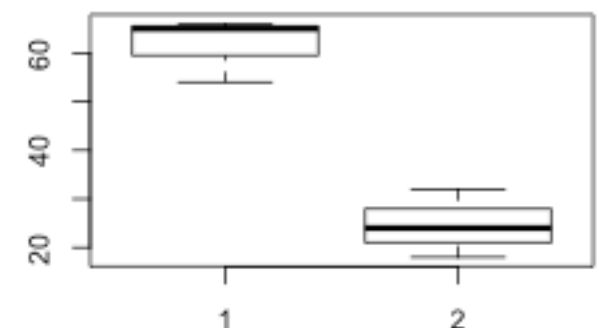
```
data.frame$proteobacteria
```

```
[1] 54 65 66 32 24 18
```

```
t.test(data.frame$proteobacteria[1:3],  
data.frame$proteobacteria[4:6])
```

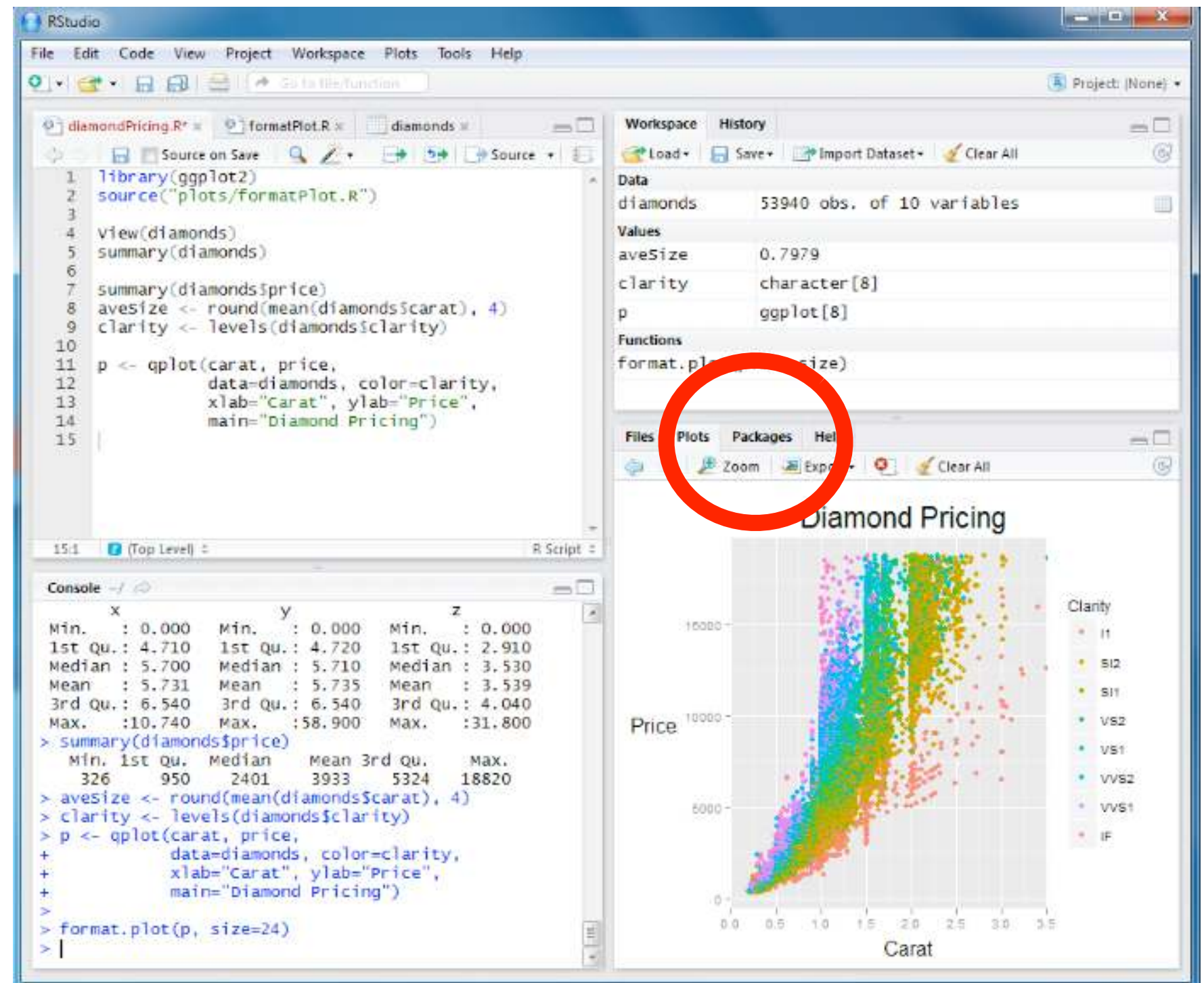
```
p-value = 0.002725
```

```
boxplot(data.frame$proteobacteria[1:3],  
data.frame$proteobacteria[4:6])
```



Basic R Mechanics

R Mechanics - Installing Packages



`install.packages("vegan")`

Getting Data Into and Out of R

Step 1: Start a new R project

Step 2: Read in some data

```
bacteria <- read.table("bacterial_table.txt")
```

Step 3: Work with data

```
bacteria_2 <- bacteria[-2]
```

Step 4: Write data

```
write.table(bacteria_2, file="updated_bacteria")
```

Getting Help in R

?write.table

Description

`write.table` prints its required argument `x` (after converting it to a data frame if it is not one nor a matrix) to a file or [connection](#).

Usage

```
write.table(x, file = "", append = FALSE, quote = TRUE, sep = " ",
            eol = "\n", na = "NA", dec = ".", row.names = TRUE,
            col.names = TRUE, qmethod = c("escape", "double"),
            fileEncoding = "")
```

```
write.csv(...)
write.csv2(...)
```

Arguments

<code>x</code>	the object to be written, preferably a matrix or data frame. If not, it is attempted to coerce <code>x</code> to a data frame.
<code>file</code>	either a character string naming a file or a connection open for writing. "" indicates output to the console.
<code>append</code>	logical. Only relevant if <code>file</code> is a character string. If <code>TRUE</code> , the output is appended to the file. If <code>FALSE</code> , any existing file of the name is destroyed.

R Studio Overview
