Graphics

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Agenda

- Basic graphics
- Custom graphics

Functions for graphics

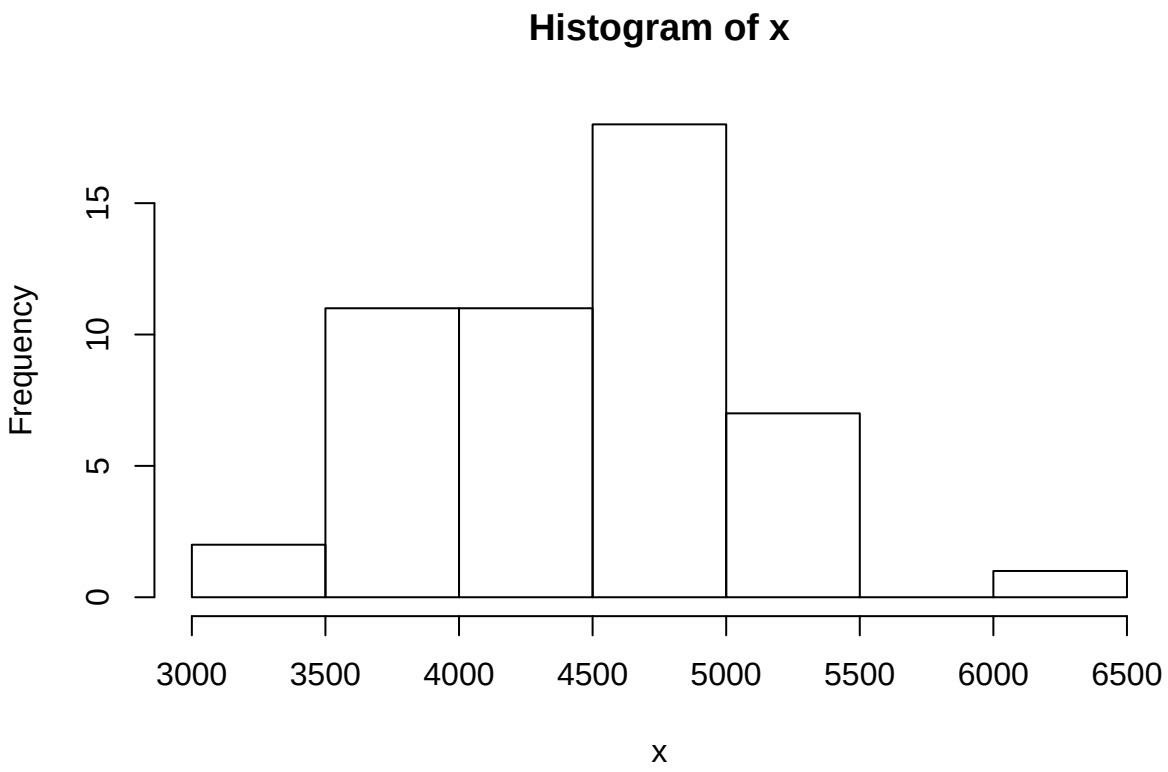
- The functions `hist()`, `boxplot()`, `plot()`, `points()`, `lines()`, `text()`, `mtext()`, `axis()`, etc. form a suite that plot graphs and add features to the graph
- Each of these functions have various options, to learn more about them, use the help
- `par()` can be used to set or query graphical parameters

Basic graphics

- Univariate data:
  - continuous: density plots(histogram and kernel density plots), ecdf
  - Categorical: pie charts, bar charts
- Bivariate data:
  - Two continuous data: Sscatterplots, qqplots
  - One contunuous and one categorical data: boxplots
  - Two categorical data: stacked/grouped bar charts
- Trivariate data:
  - pairwise plots
  - 3D plots(image plots, coutour plots)

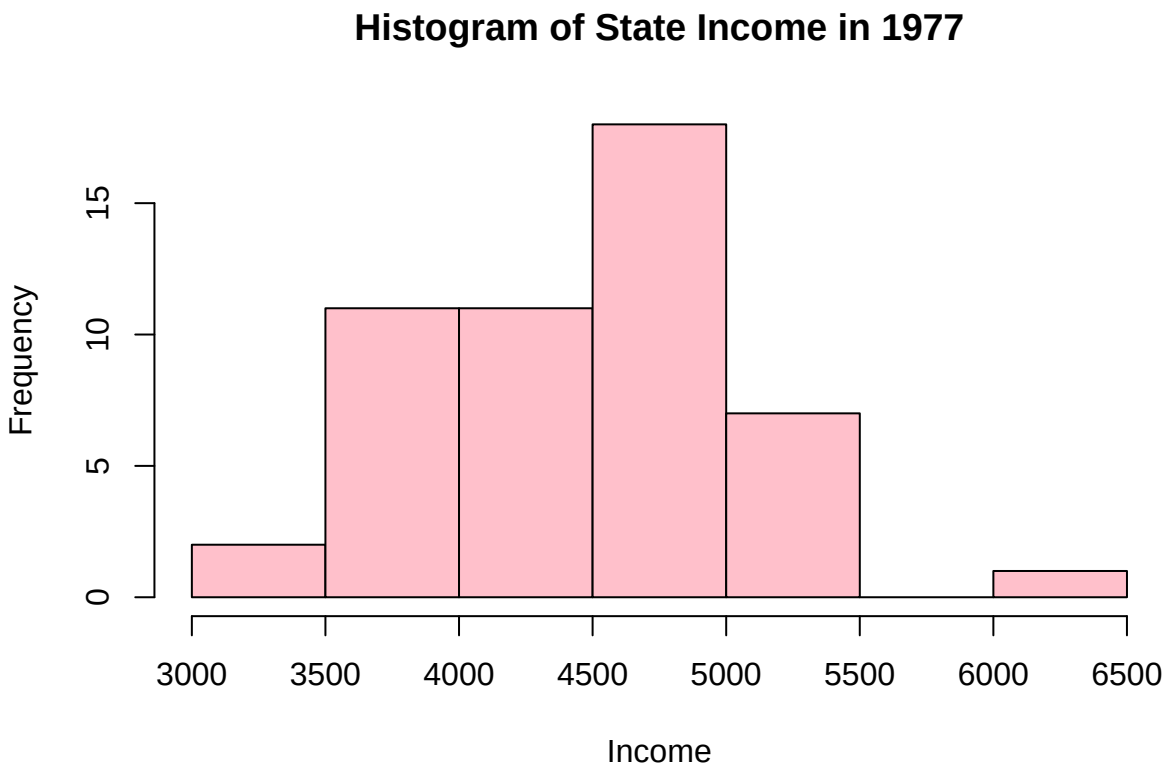
Univariate data: Histogram

```
x <- state.x77[, 2]            # 50 average state incomes in 1977
hist(x)
```



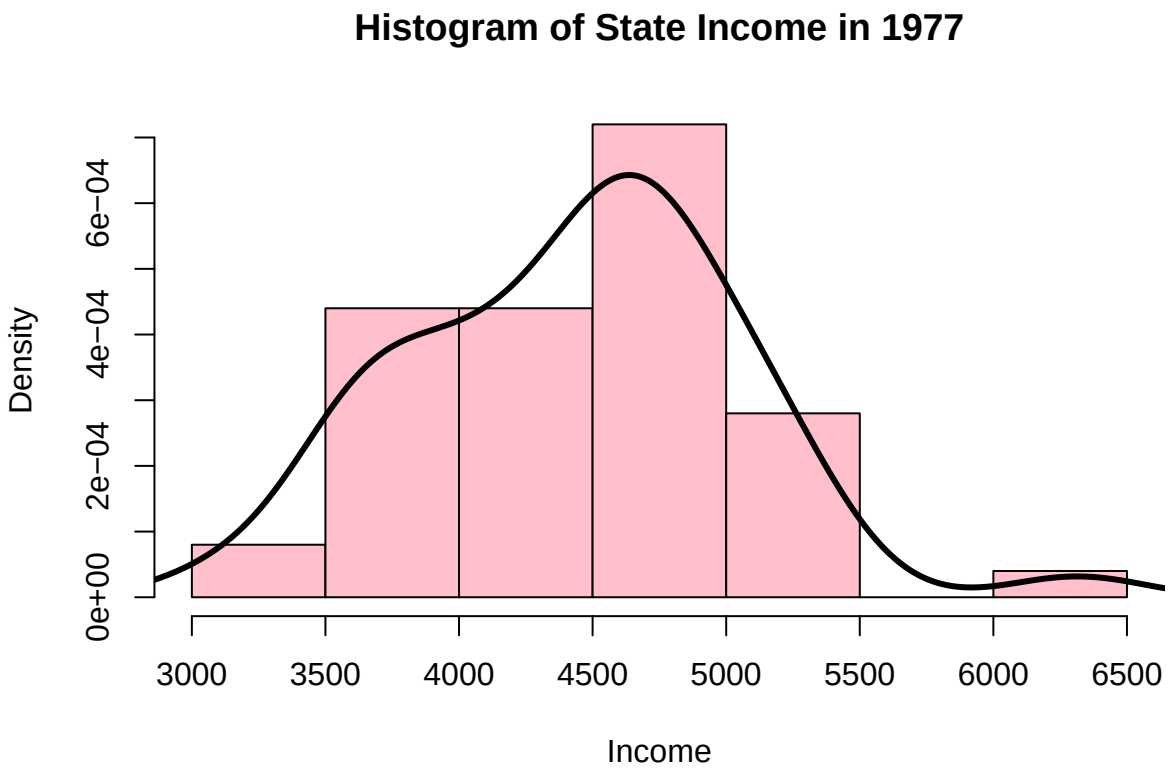
Univariate data: Histogram

```
hist(x, breaks = 8, col="pink", xlab="Income", main="Histogram of State Income in 1977")
```



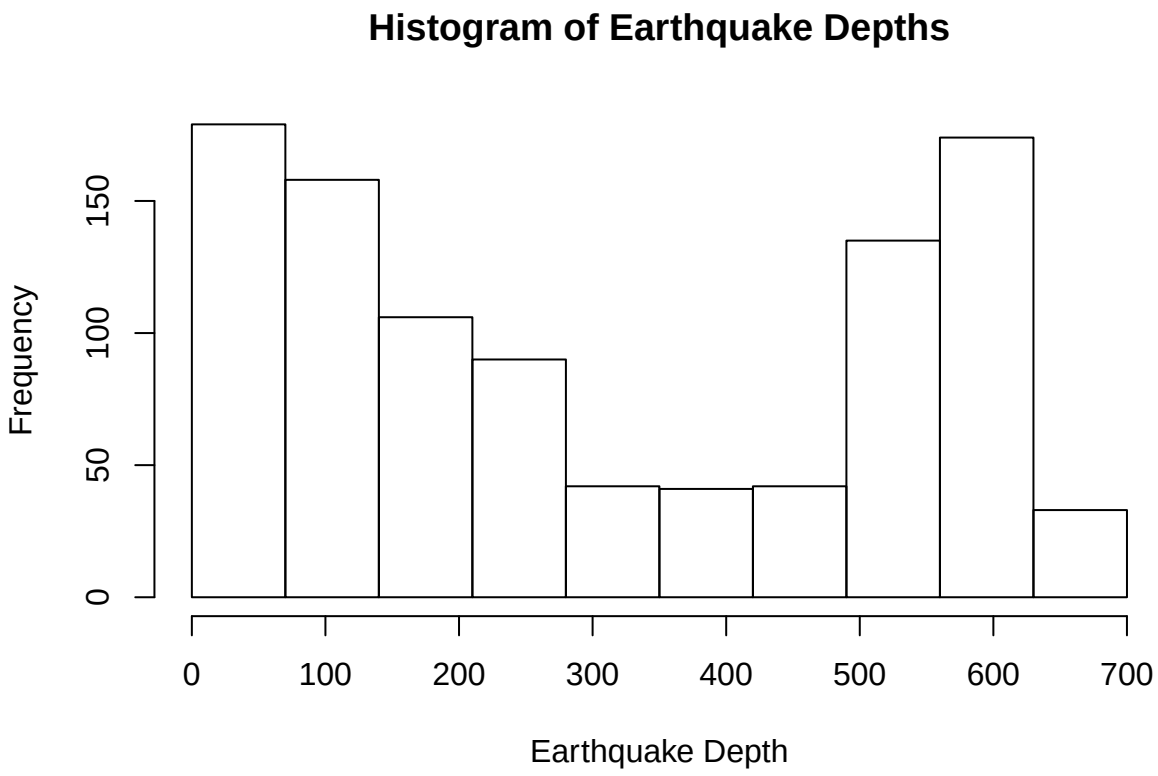
Univariate data: Histogram with a density plot

```
hist(x, breaks = 8, col="pink", freq = FALSE, xlab="Income", main="Histogram of State Income in 1977")
lines(density(x), lwd=3)
```



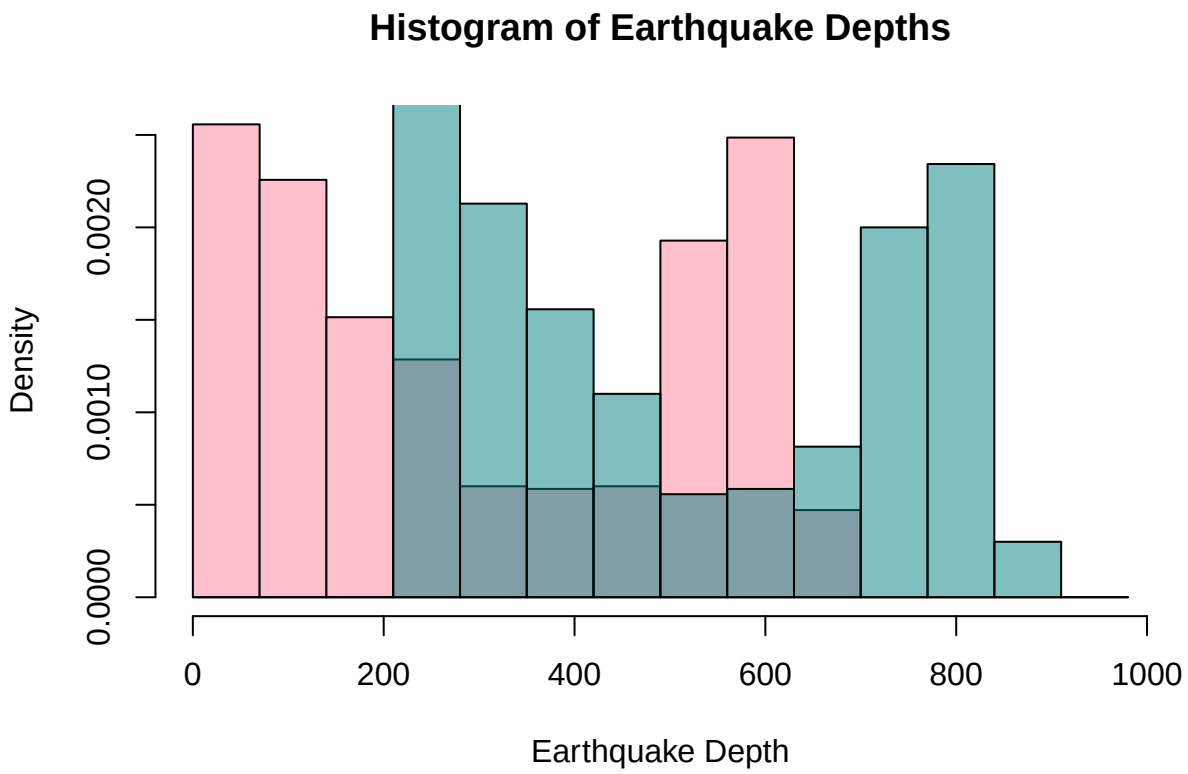
Univariate data: Histogram

```
y <- quakes$depth                          # 1000 earthquake depths
hist(y, seq(0, 700, by = 70), xlab="Earthquake Depth", main="Histogram of Earthquake Depths")
```



Univariate data: Histogram

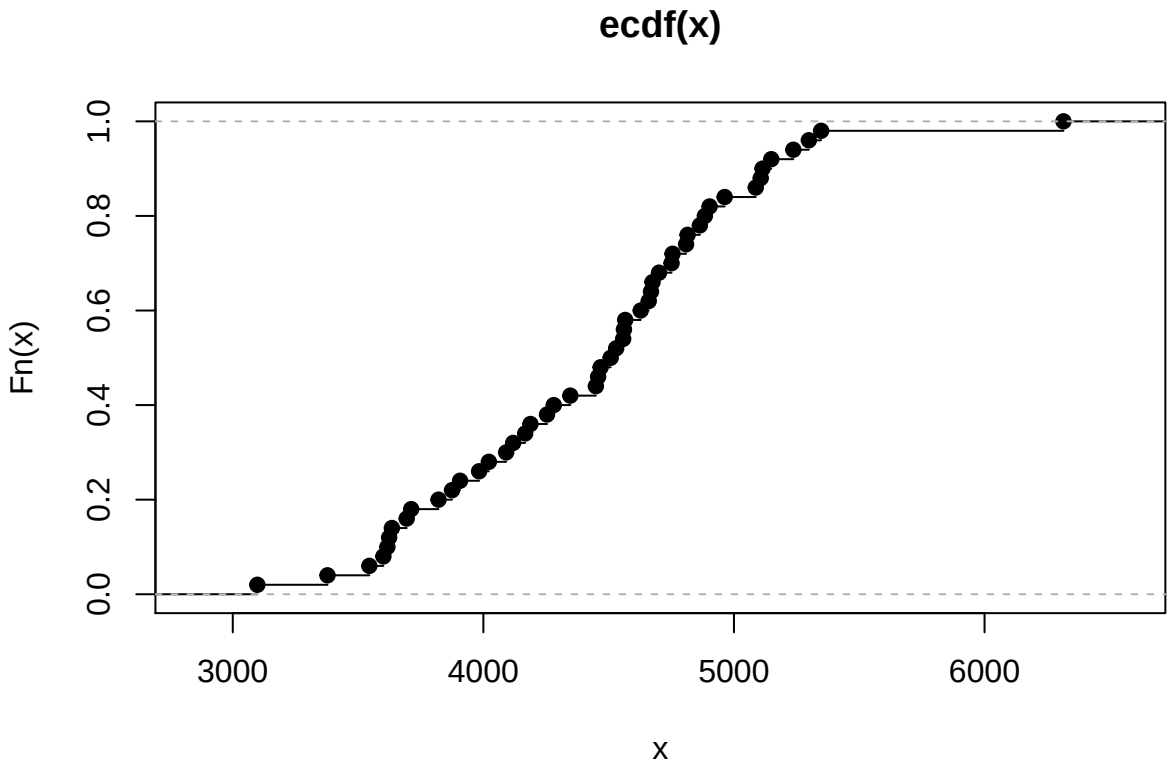
```
y <- quakes$depth                          # 1000 earthquake depths
hist(y, seq(0, 1000, by = 70), freq = FALSE, col = "pink",
     xlab="Earthquake Depth", main="Histogram of Earthquake Depths")
hist(y+ 200, seq(0, 1000, by = 70), freq = FALSE, col = rgb(0,0.5, 0.5, 0.5), add = TRUE)
```



Univariate data: Empirical CDF

Function `plot.ecdf()` provides data for empirical cdf

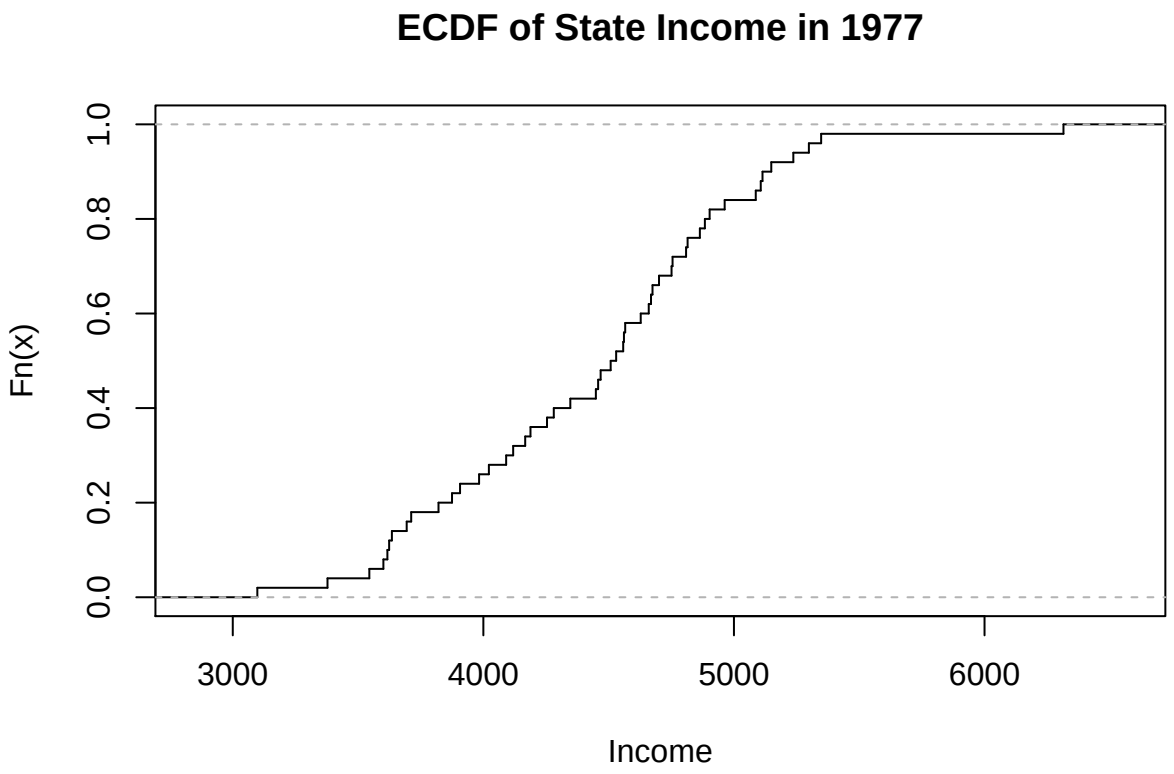
```
plot.ecdf(x)
```



Univariate data: Empirical CDF

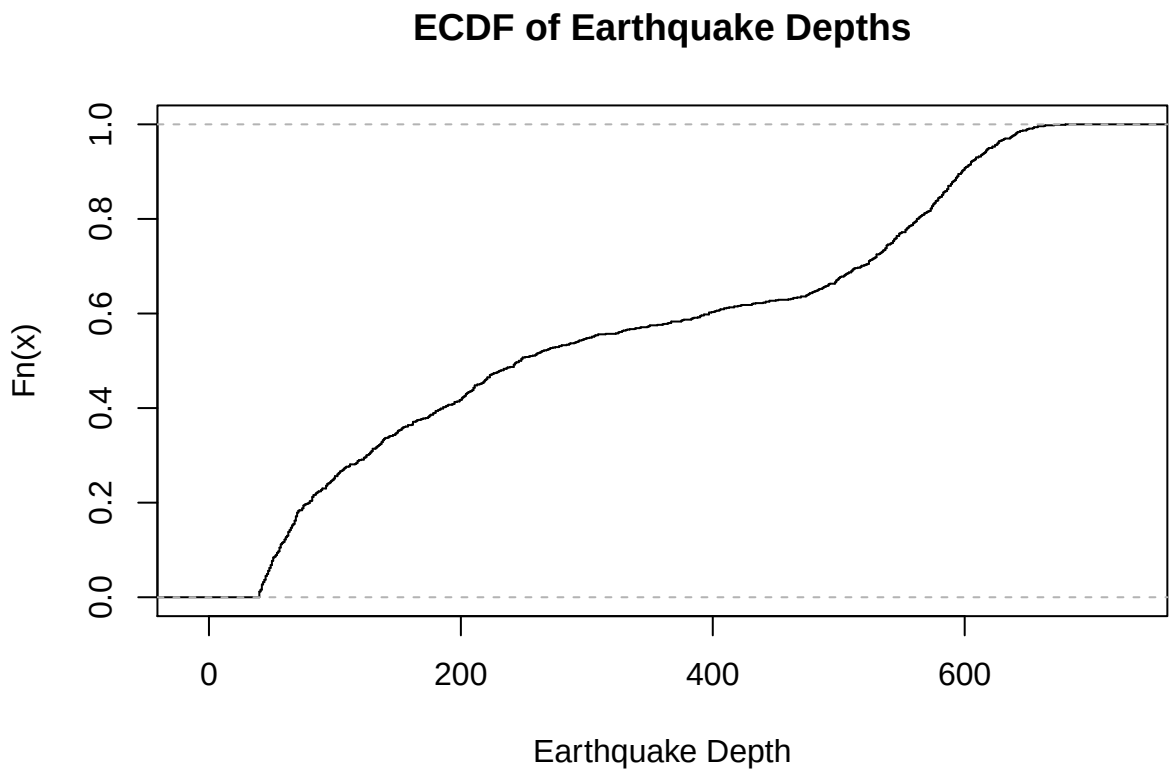
Can add vertical lines and remove dots

```
plot.ecdf(x, verticals = T, pch = "", xlab = "Income",
          main = "ECDF of State Income in 1977")
```



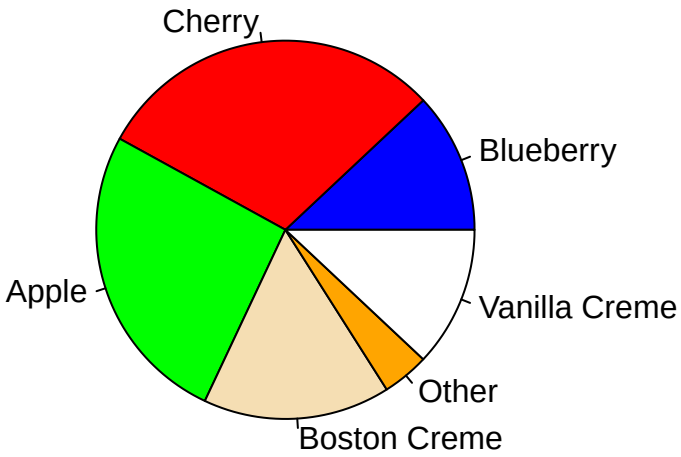
Univariate data: Empirical CDF

```
plot.ecdf(y, verticals = T, pch = "", xlab = "Earthquake Depth",
          main = "ECDF of Earthquake Depths")
```



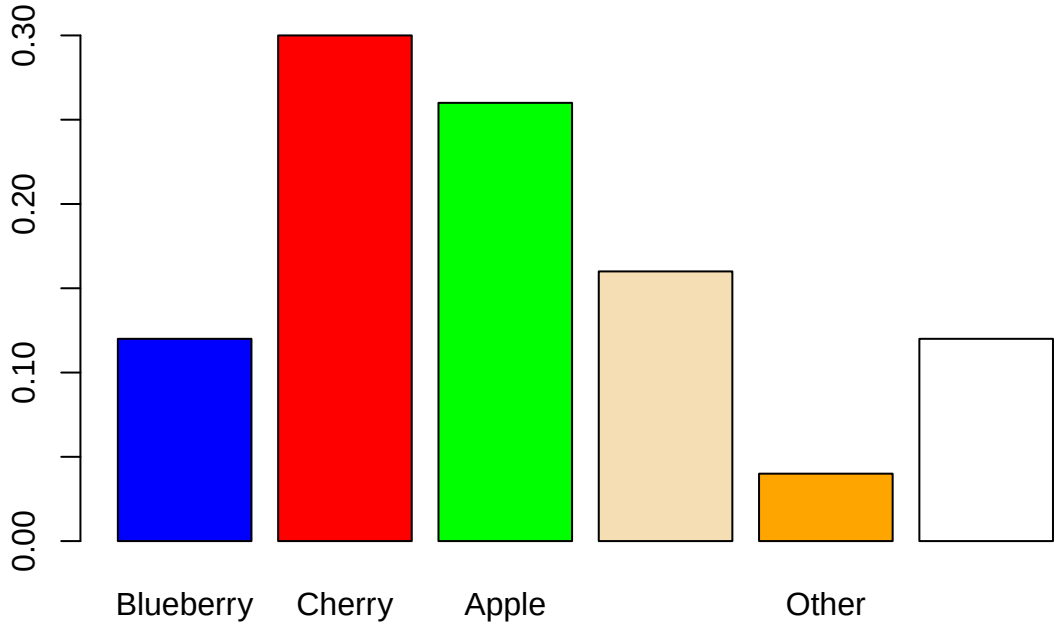
Univariate data: Pie charts

```
pie.sales = c(0.12, 0.30, 0.26, 0.16, 0.04, 0.12)
names(pie.sales) = c("Blueberry", "Cherry", "Apple", "Boston Creme",
                     "Other", "Vanilla Creme")
pie(pie.sales, col = c("blue", "red", "green", "wheat", "orange", "white"))
```

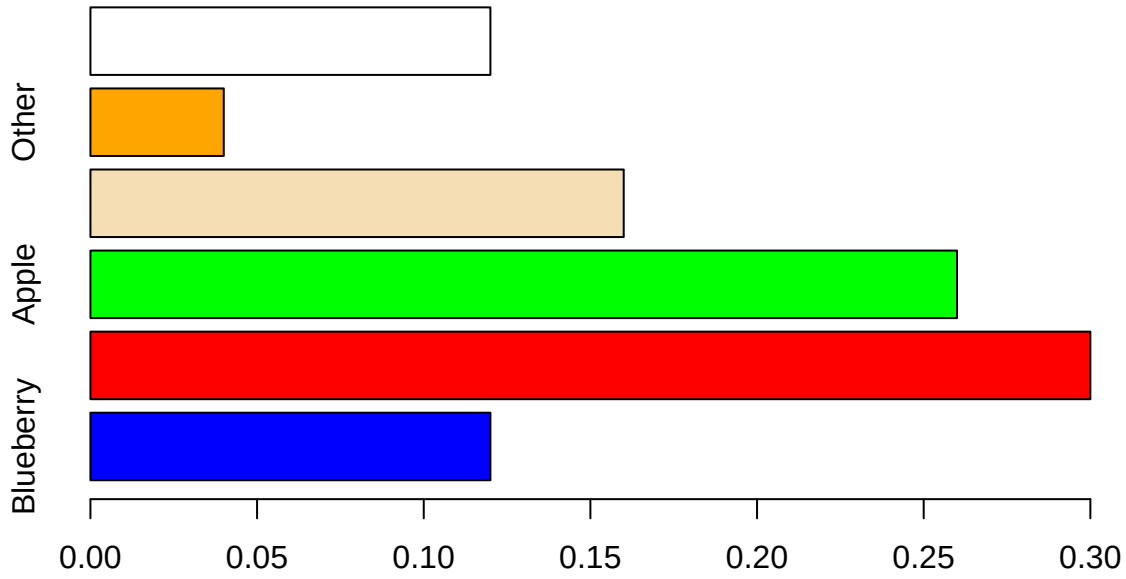


Univariate data: bar charts

```
barplot(pie.sales, col = c("blue", "red", "green", "wheat", "orange", "white"))
```



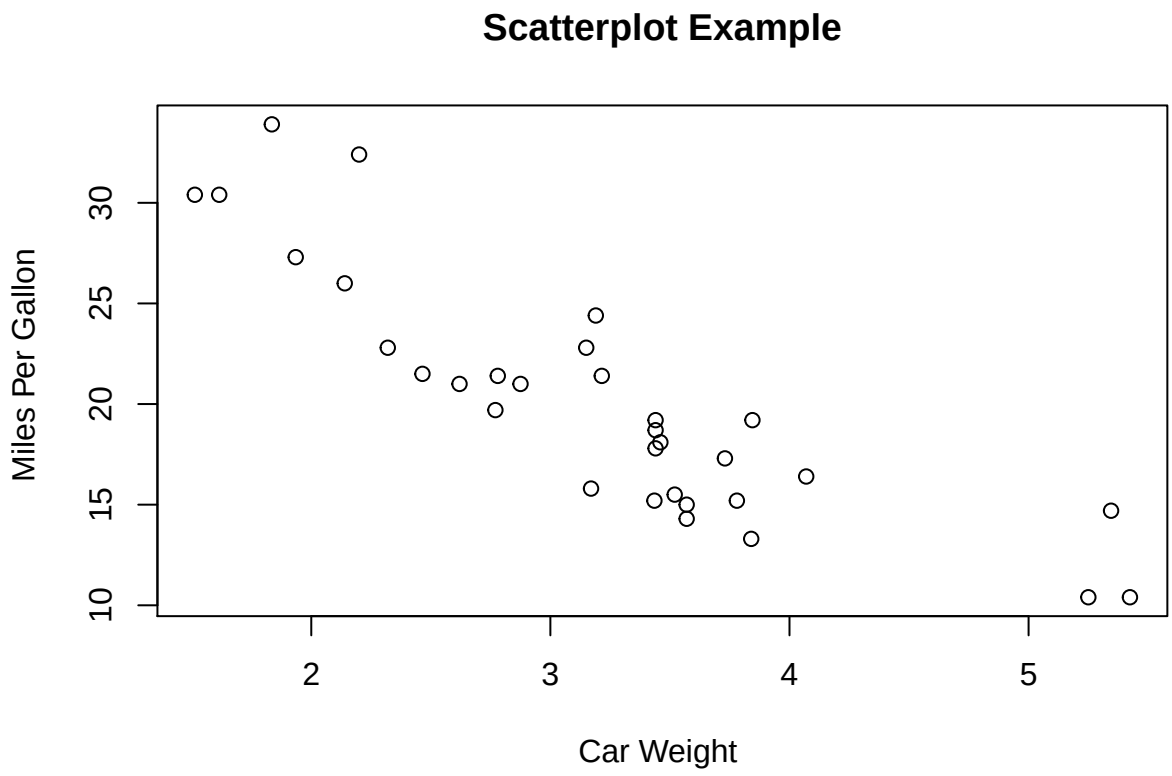

```
barplot(pie.sales, col = c("blue", "red", "green", "wheat", "orange", "white"), horiz = TRUE)
```



Bivariate data

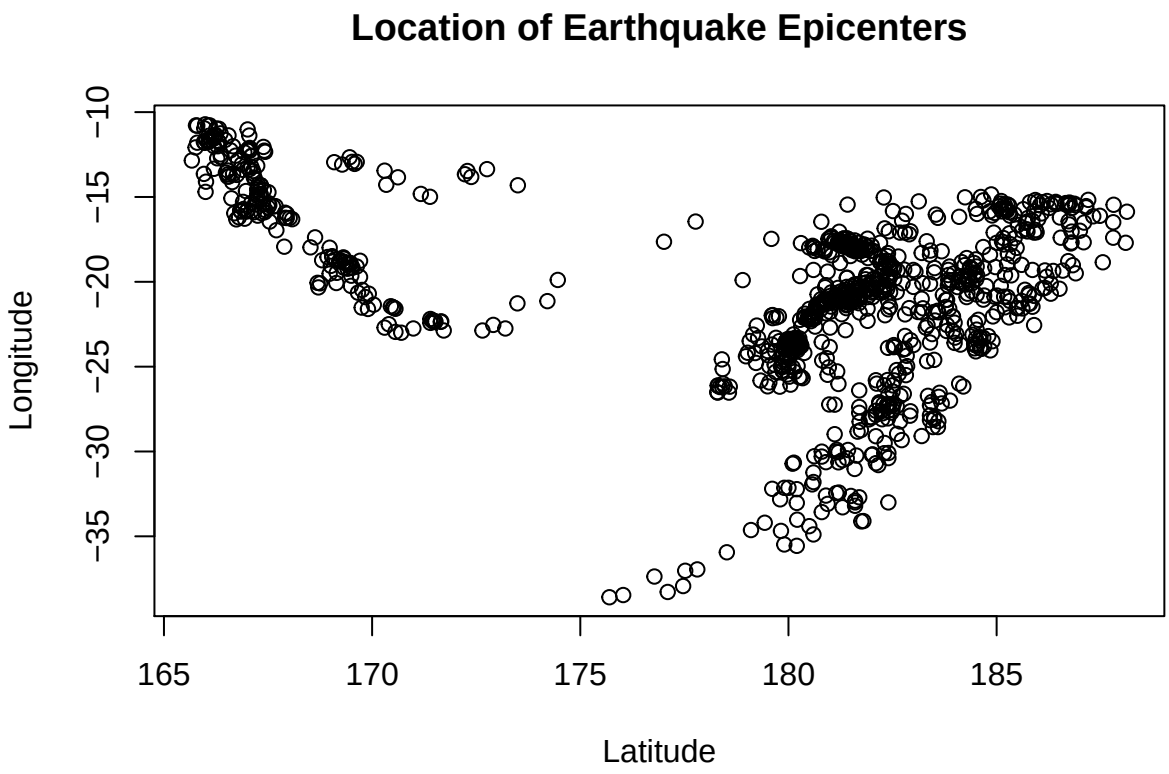
Scatterplots: `plot(x, y)`

```
# Simple Scatterplot
attach(mtcars)
plot(wt, mpg, main="Scatterplot Example",
   xlab="Car Weight ", ylab="Miles Per Gallon ")
```



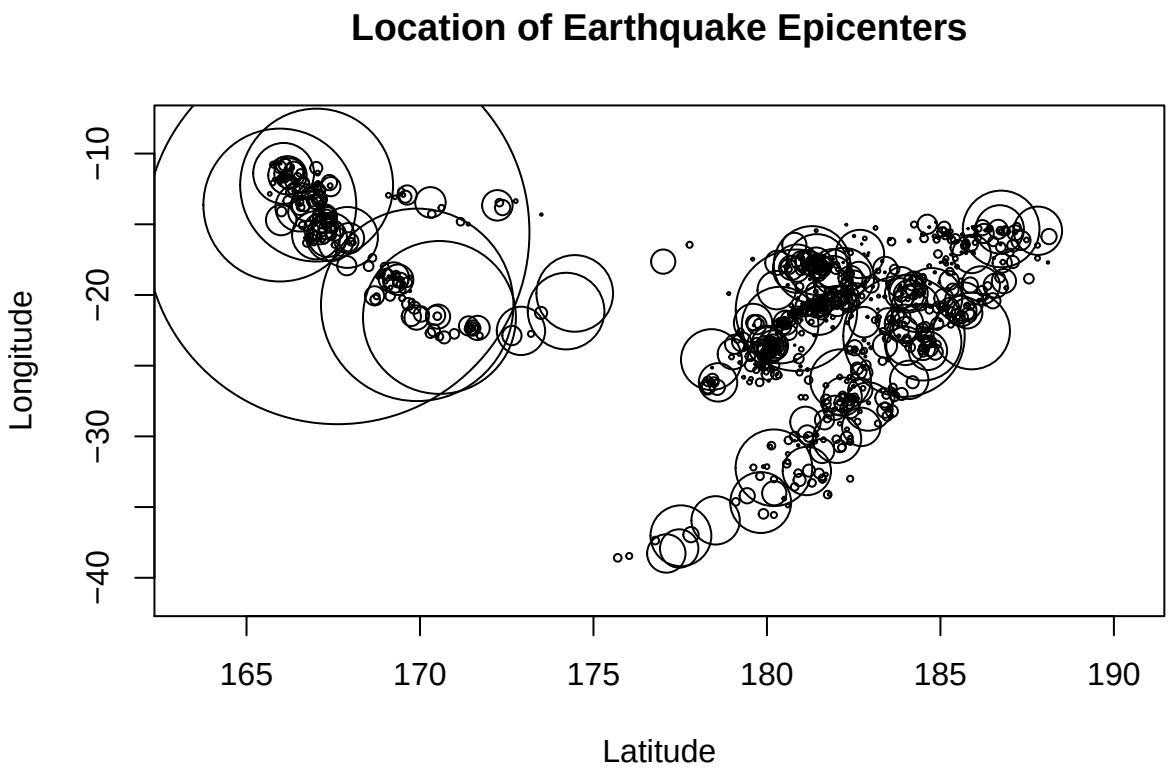

```
detach(mtcars)
```

```
plot(quakes$long, quakes$lat, xlab="Latitude", ylab="Longitude",
     main="Location of Earthquake Epicenters")
```



Scatterplots: `plot(x, y)`

```
symbols(quakes$long, quakes$lat, circles = 10 ^ quakes$mag,
        xlab="Latitude", ylab="Longitude",
        main="Location of Earthquake Epicenters")
```

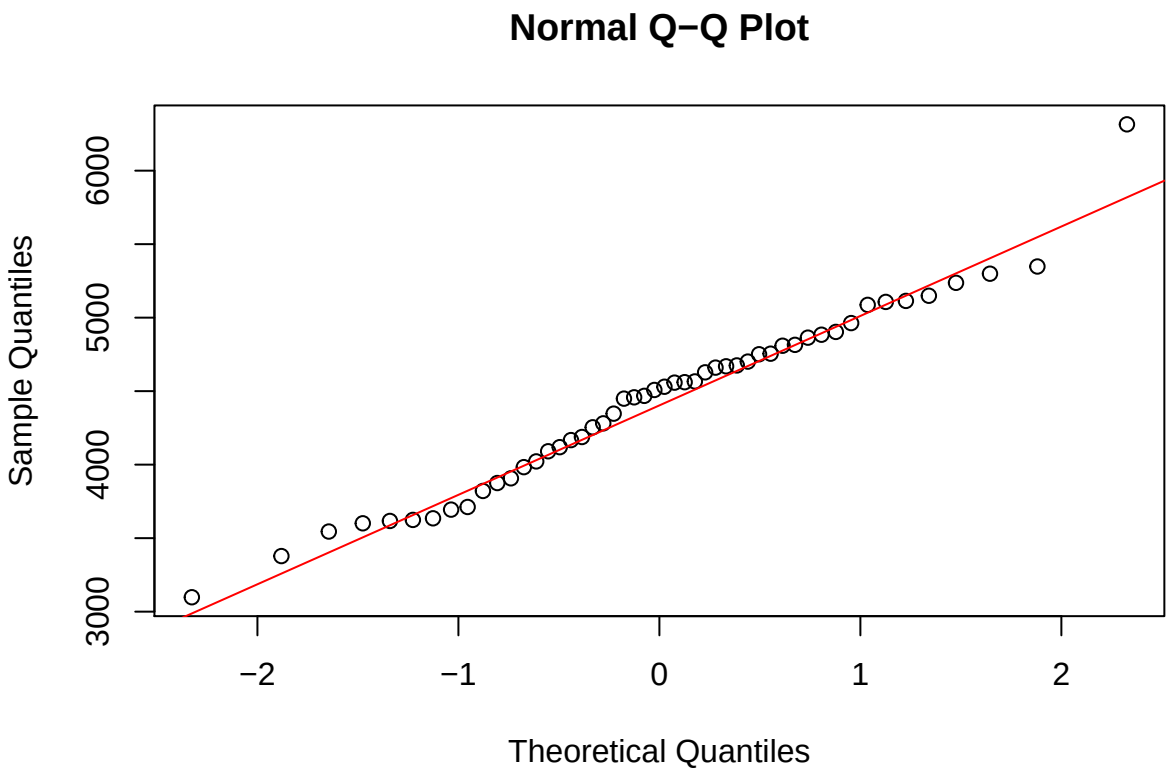


qqnorm() and qqplot()

- `qqnorm()` plots the quantiles of a data set against the quantiles of a Normal distribution
- `qqplot()` plots the quantiles of a first data set against the quantiles of a second data set

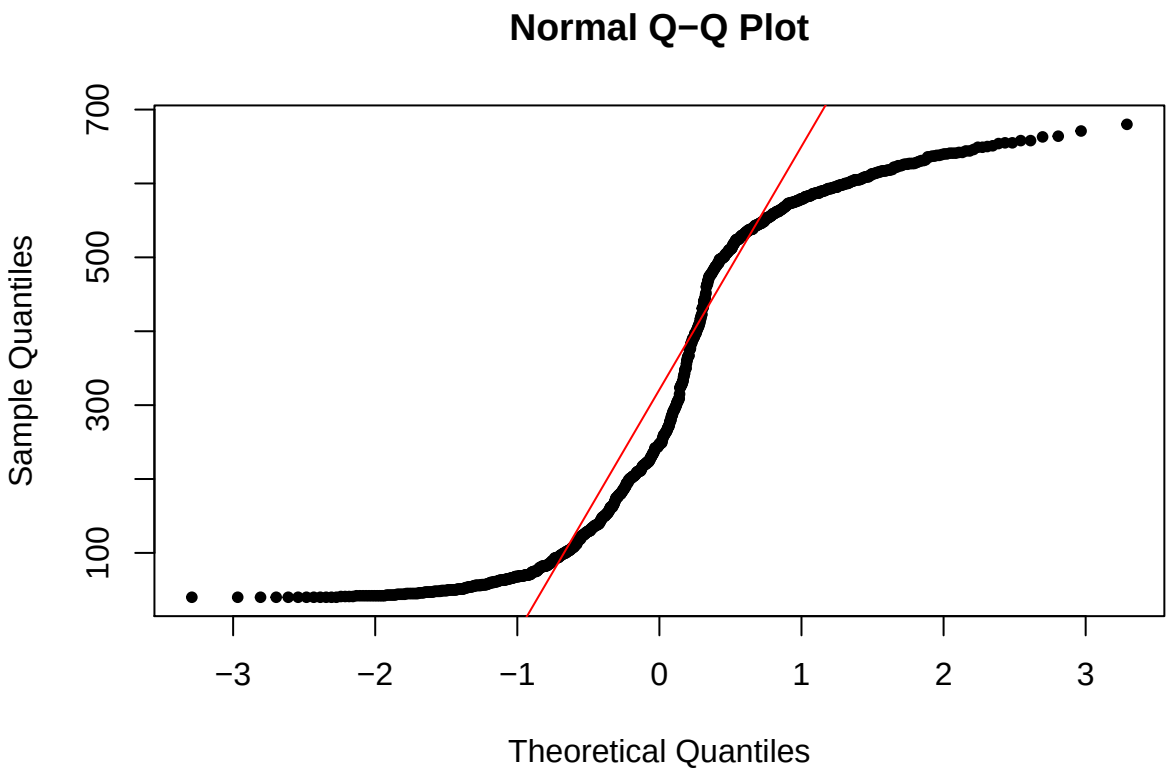
qqnorm() and qqplot()

```
qqnorm(x)                    # qq plot for the earthquake depths
qqline(x, col = "red")        # red reference line
```



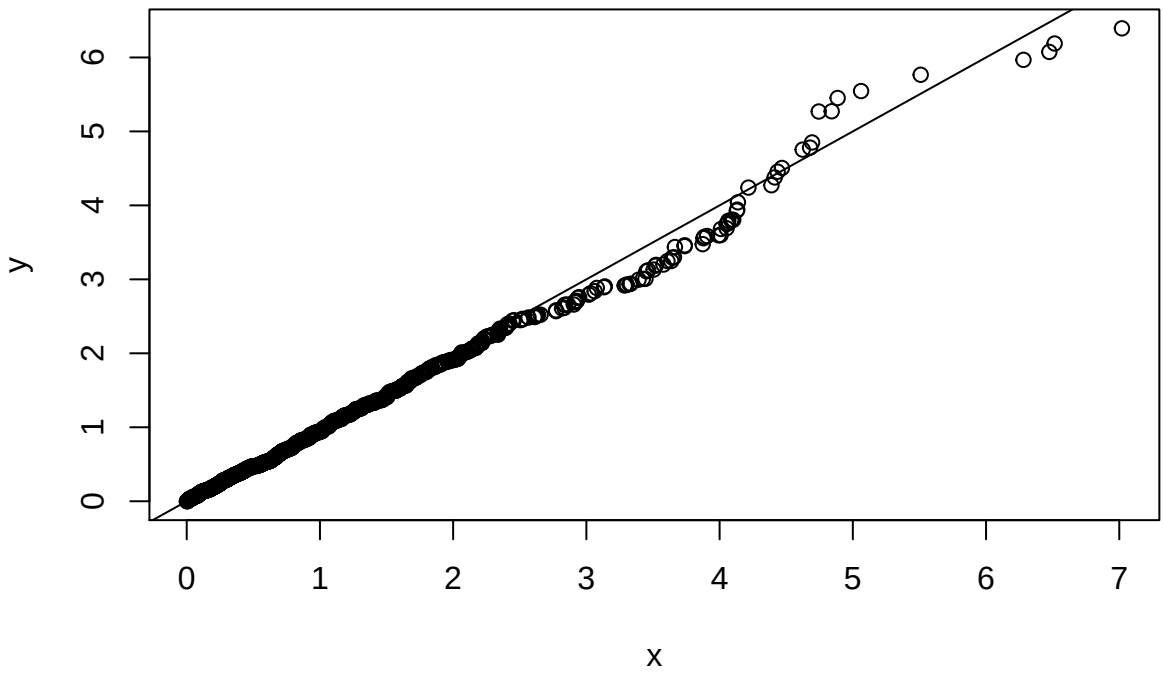
qqnorm() and qqplot()

```
qqnorm(y, pch=20)                    # qq plot for the earthquake depths
qqline(y, col = "red")         # red reference line
```



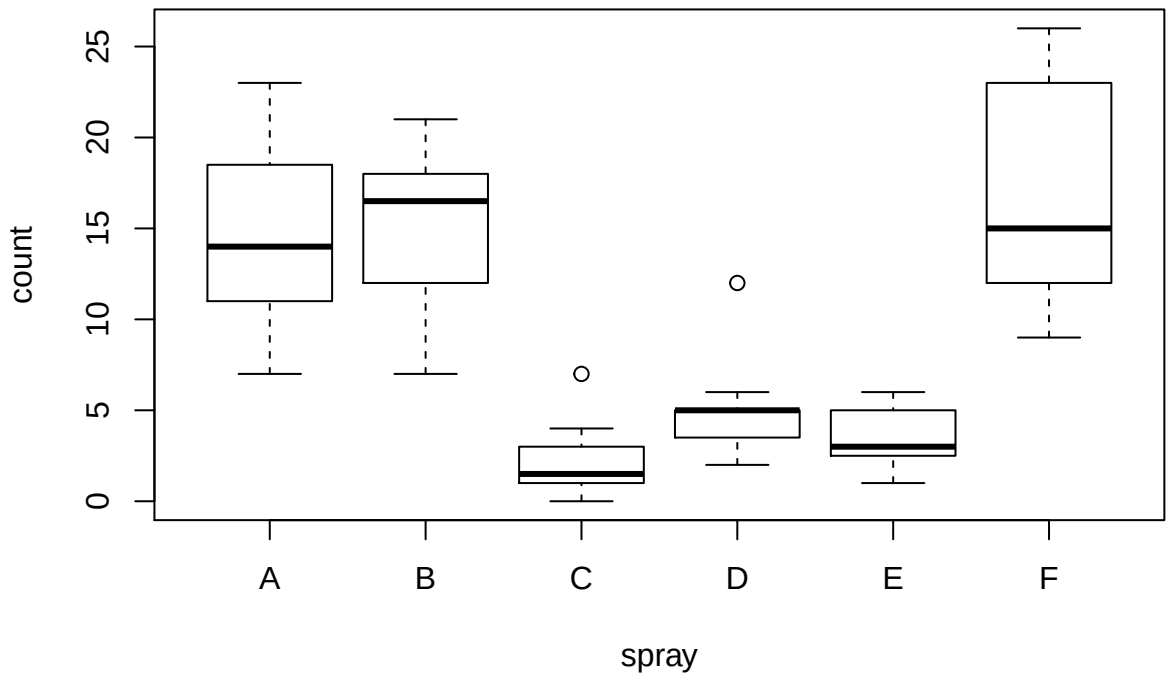
qqnorm() and qqplot()

```
x <- rexp(1000)
y <- rexp(1000)
qqplot(x,y)
abline(a=0,b=1)
```



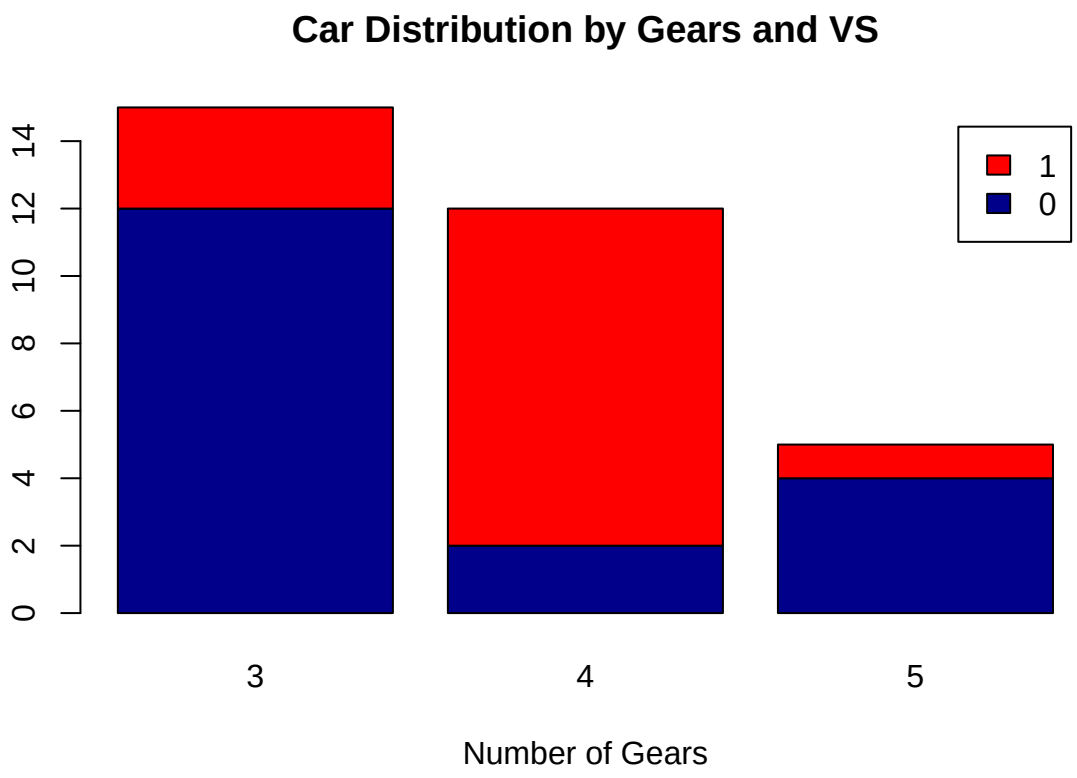
Box plots

```
boxplot(count ~ spray, data = InsectSprays)
```



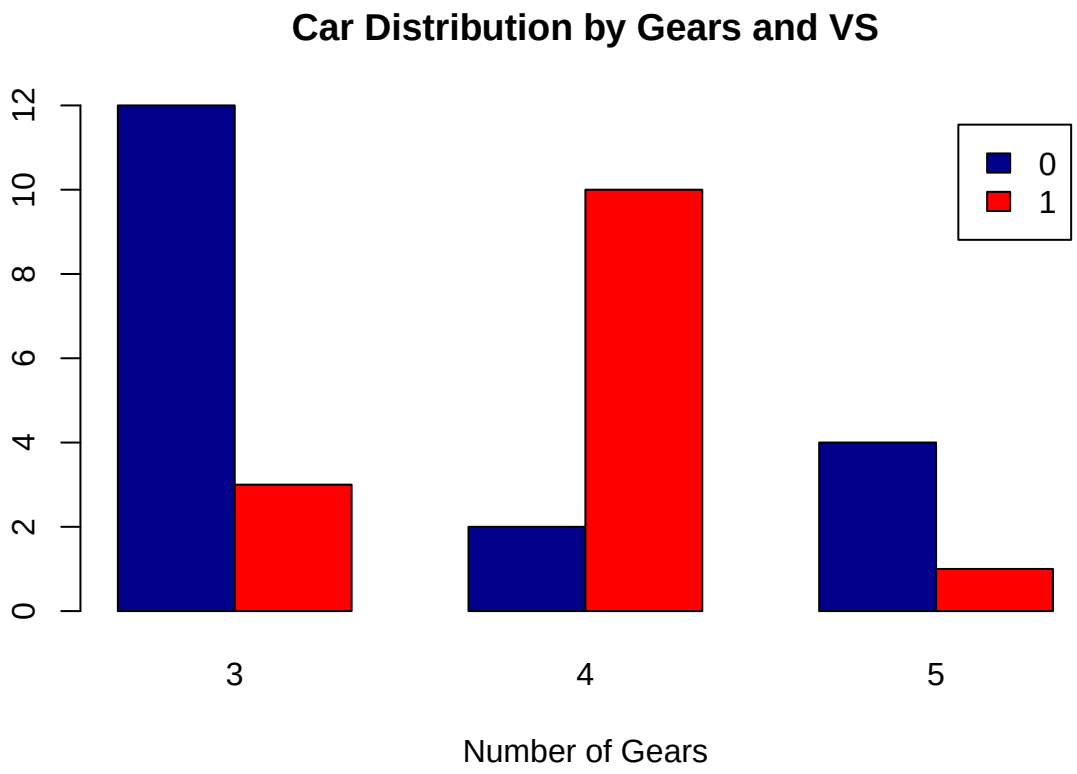
Stacked Bar plot

```
counts <- table(mtcars$vs, mtcars$gear)
barplot(counts, main="Car Distribution by Gears and VS",
  xlab="Number of Gears", col=c("darkblue","red"),
  legend = rownames(counts))
```



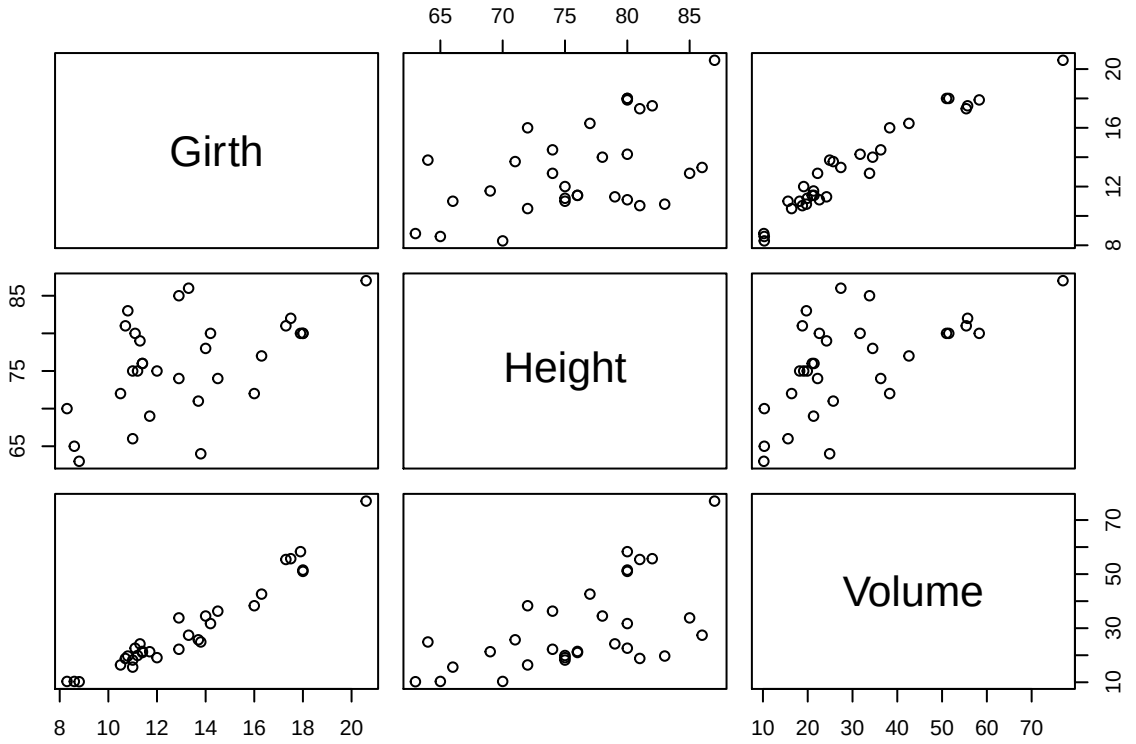
Grouped Bar Plot

```
counts <- table(mtcars$vs, mtcars$gear)
barplot(counts, main="Car Distribution by Gears and VS",
  xlab="Number of Gears", col=c("darkblue","red"),
  legend = rownames(counts), beside=TRUE)
```



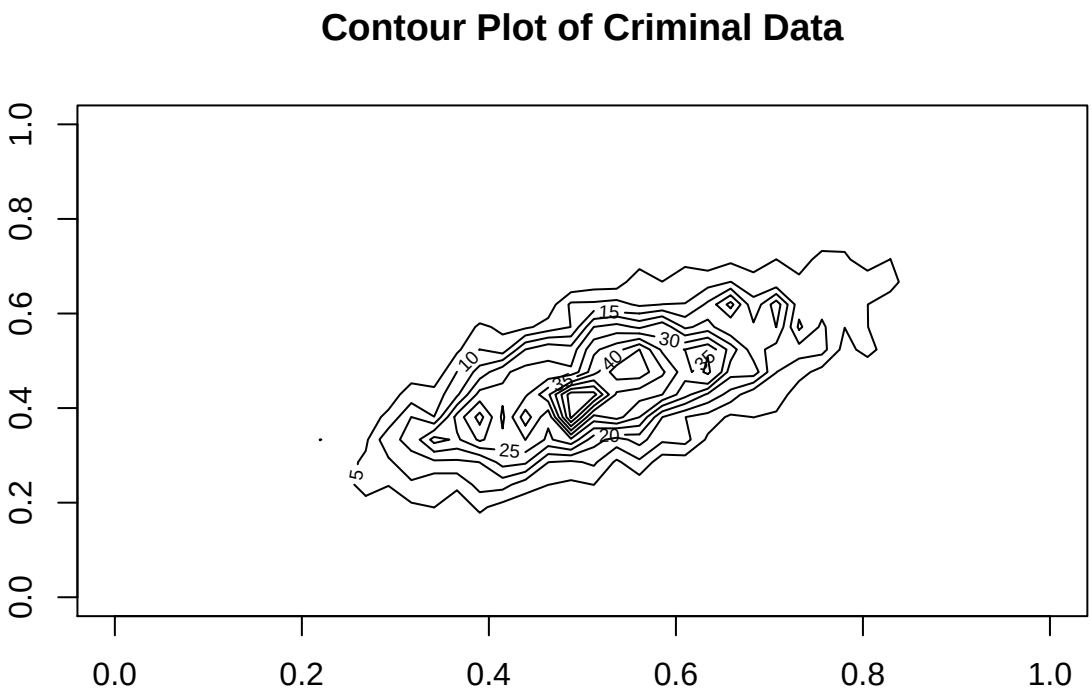
Three-dimensional data: `pairs(x)`

```
pairs(trees)
```



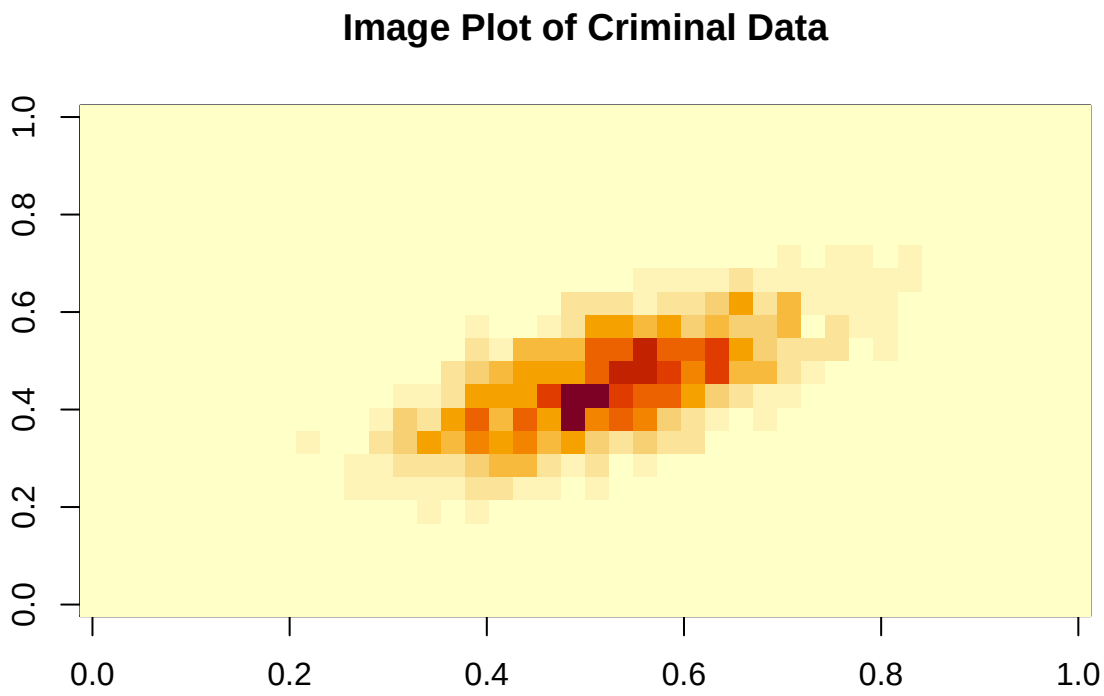
Three dimensional plots: `contour()`

```
contour(crimtab, main="Contour Plot of Criminal Data")
```

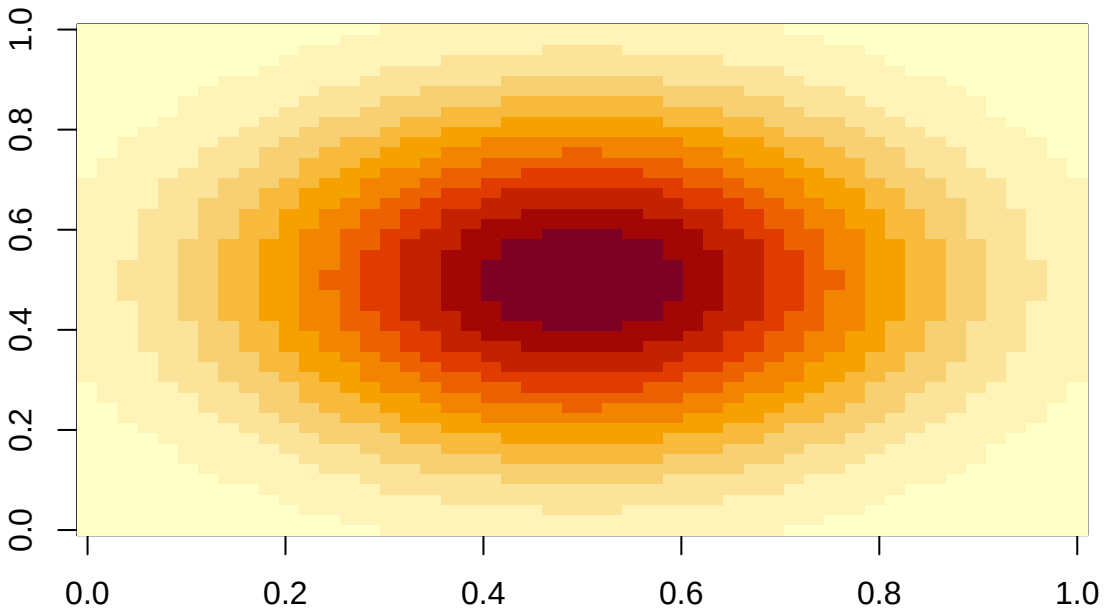


Three dimensional plots: `image()`

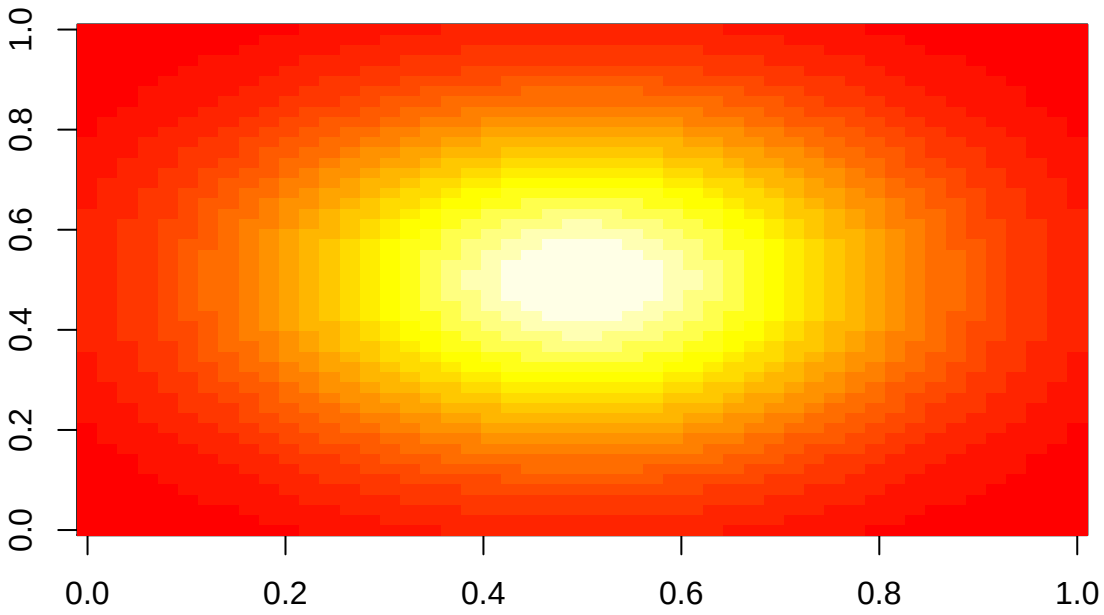
```
image(crimtab, main="Image Plot of Criminal Data")
```



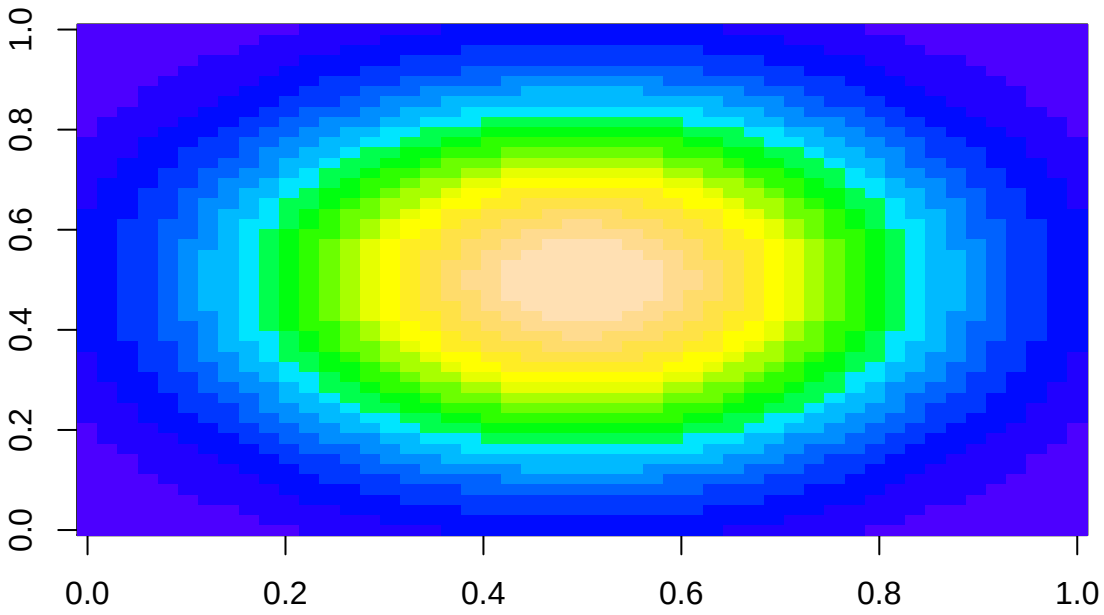

```
phi <- dnorm(seq(-2,2,length=50))
normal.mat <- phi %o% phi
image(normal.mat)
```



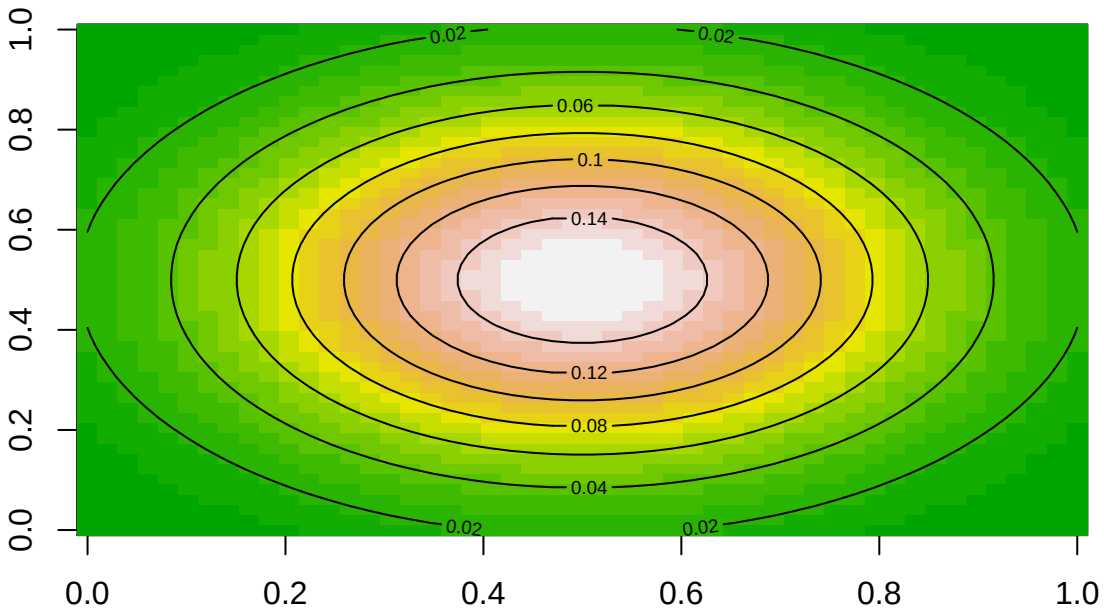

```
image(normal.mat, col=heat.colors(20))
```




```
image(normal.mat, col=topo.colors(20))
```

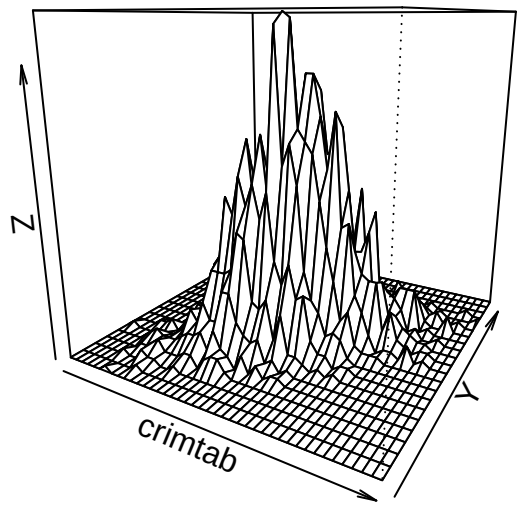



```
image(normal.mat, col=terrain.colors(20))
contour(normal.mat, add = TRUE)
```



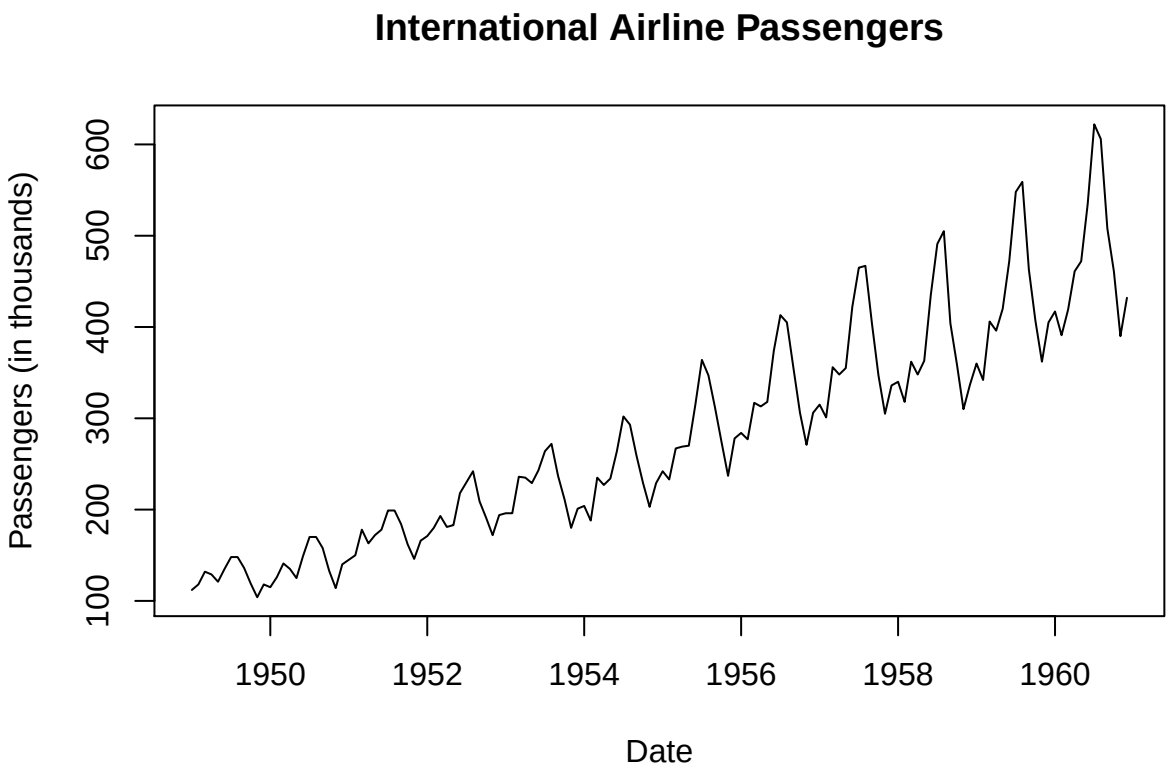
Three dimensional plots

```
persp(crimtab, theta=30, main="Perspective Plot of Criminal Data")
```



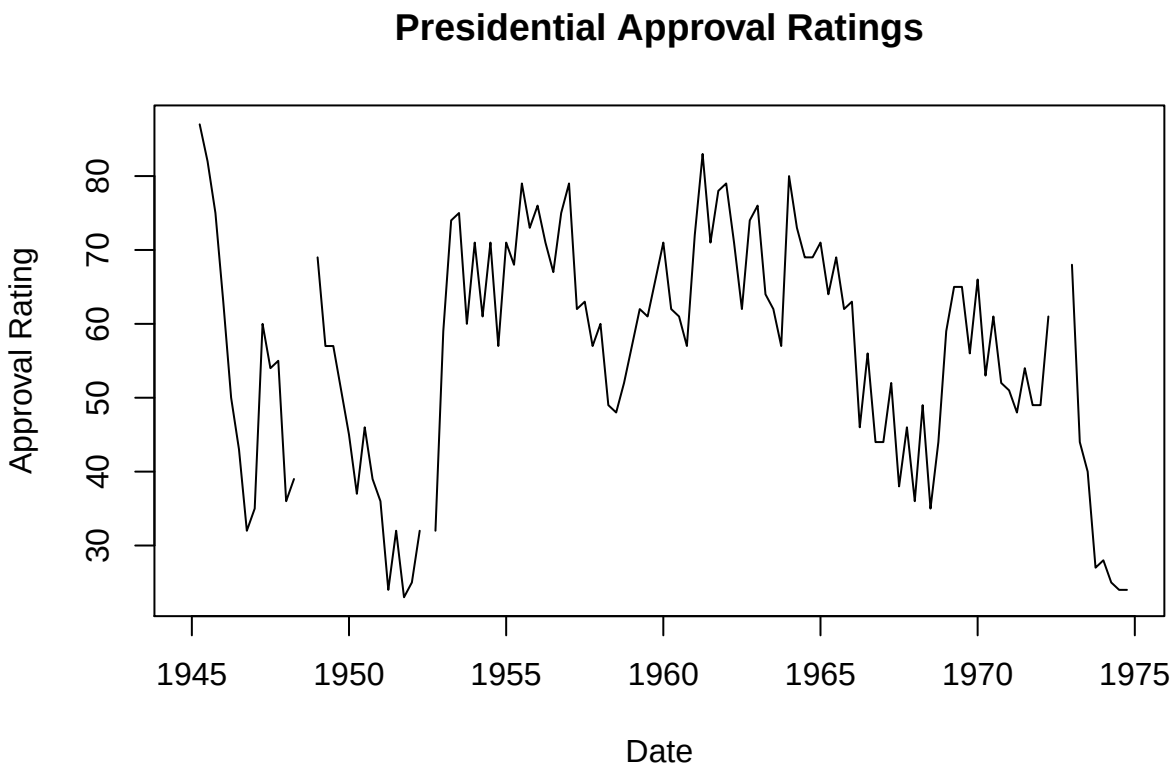
Time series plots

```
ts.plot(AirPassengers, xlab="Date", ylab="Passengers (in thousands)",
        main="International Airline Passengers")
```



Time series plots

```
ts.plot(presidents, xlab="Date", ylab="Approval Rating",
        main="Presidential Approval Ratings")
```



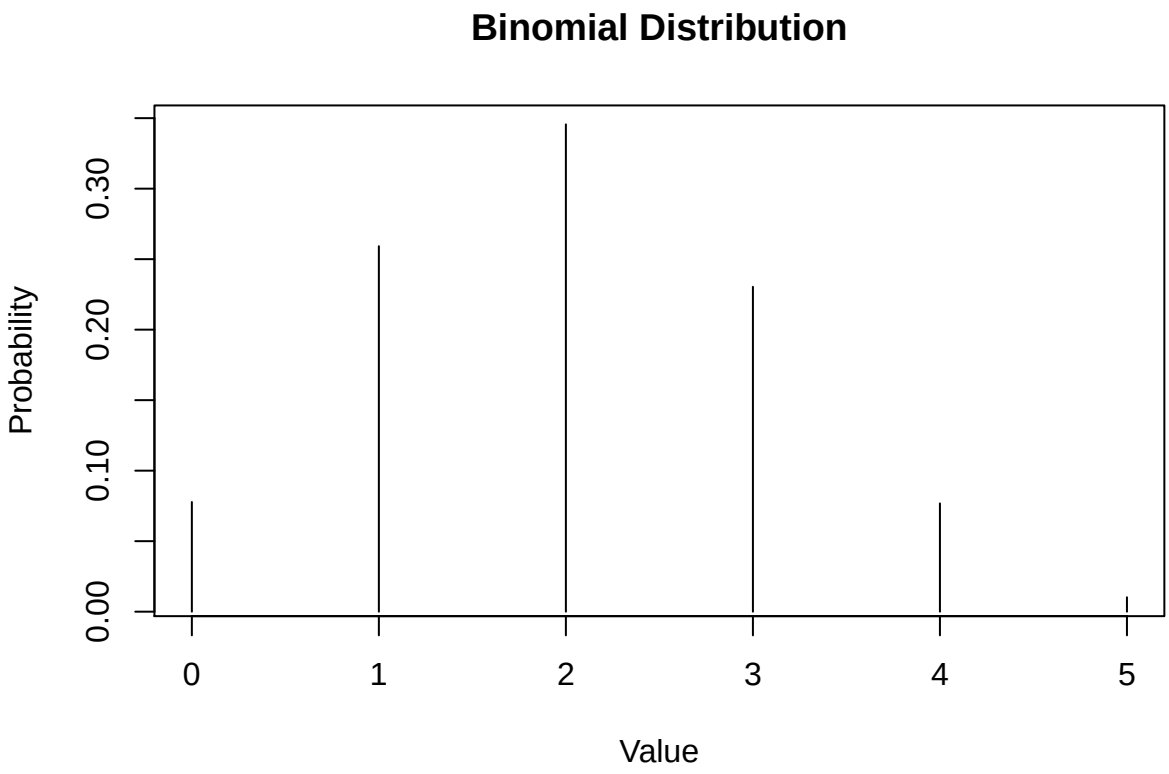
Custom graphics

- `par()` can be used to set or query graphical parameters
- We've already used some of these
- `adj`: text justification
- `bg`: background color
- `col`, `col.axis`, `col.lab`, ...: color specification
- `lty`: line type, e.g. dashed, dotted, solid (default), longdash, ...
- `lwd`: line width (helpful to increase for presentation plots)
- `mfcol` and `mfrow`: subsequent figures will be drawn in an nr-by-nc array on the device
- `pch`: point types
- `xlog`: plots to log scale if `TRUE`
- ...

Binomial distribution

Plot of binomial distribution with $n = 5$ and $p = .4$

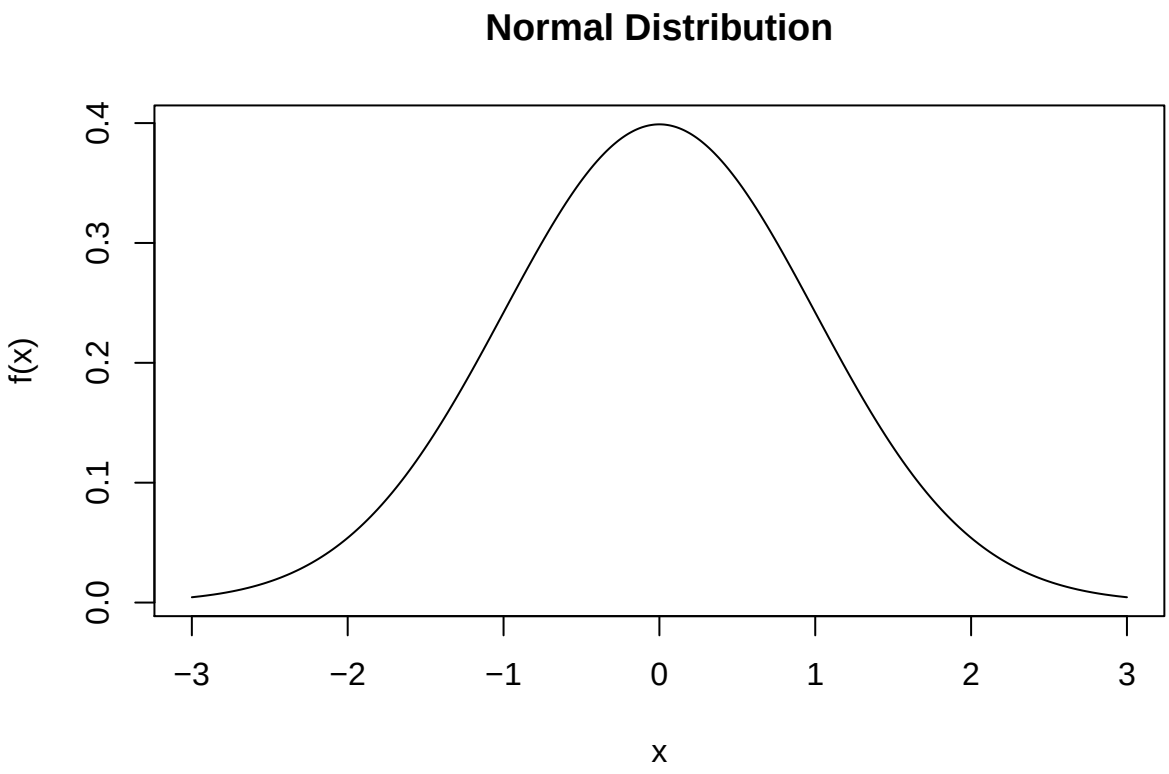
```
x <- 0:5
y <- dbinom(x, 5, 2 / 5)
plot(x, y, type = "h", main="Binomial Distribution", xlab="Value", ylab="Probability")
```



Normal distribution

Probability density function for the standard Normal distribution from -3 to 3

```
x <- seq(-3, 3, by = 0.01)
y <- dnorm(x)
plot(x, y, type = "l", main="Normal Distribution", ylab="f(x)")
```

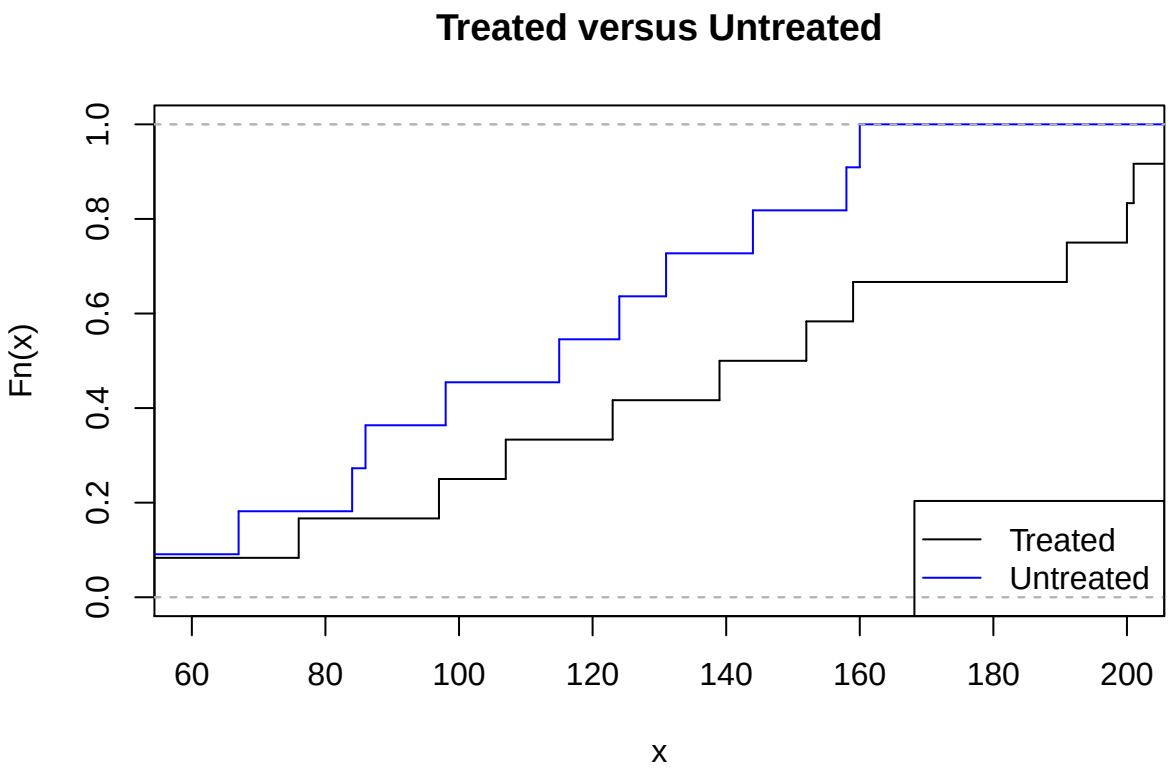


Two empirical cdfs: `Puromycin` dataset

```
x <- Puromycin$rate[Puromycin$state == "treated"]
y <- Puromycin$rate[Puromycin$state == "untreated"]
```

Two empirical cdfs: `Puromycin` dataset

```
plot.ecdf(x, verticals = TRUE, pch = "", xlim = c(60, 200), main="Treated versus Untreated")
lines(ecdf(y), verticals = TRUE, pch = "", xlim = c(60, 200), col="blue")
legend("bottomright", c("Treated", "Untreated"), pch = "", col=c("black", "blue"), lwd = 1)
```



Saving a plot to a file

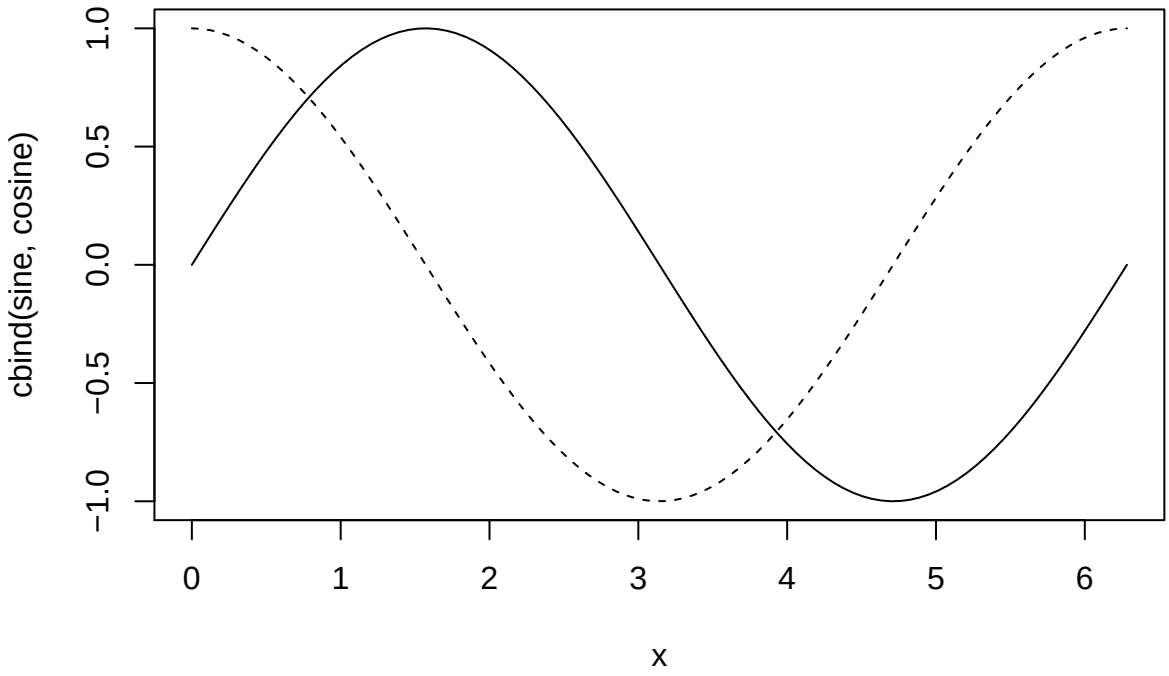
- Begin with functions `postscript()`, `pdf()`, `tiff()`, `jpeg()`, ...
- ... put all your plotting commands here ...
- Finish with `dev.off()`

```
pdf("2cdfs.pdf", width=6, height=4)
plot.ecdf(x, verticals = TRUE, pch = "", xlim = c(60, 200), main="Treated versus Untreated")
lines(ecdf(y), verticals = TRUE, pch = "", xlim = c(60, 200), col="blue")
legend("bottomright", c("Treated", "Untreated"), pch = "", col=c("black", "blue"), lwd = 1)
dev.off()
```

```
## pdf
##   2
```

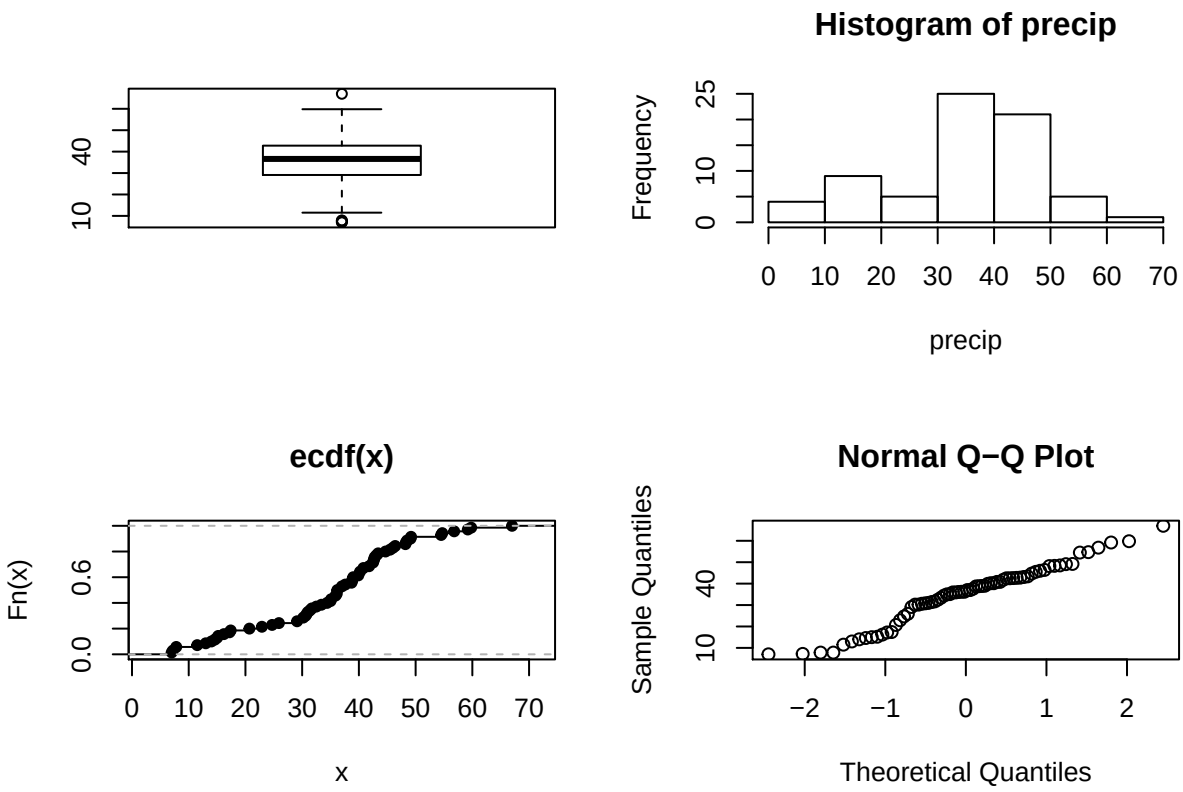
Multiple plots on one set of axes

```
x <- seq(0, 2 * pi, length = 100)
sine <- sin(x)
cosine <- cos(x)
matplot(x, cbind(sine, cosine), col = c(1, 1), type = "l")
```



Multiple frame plots

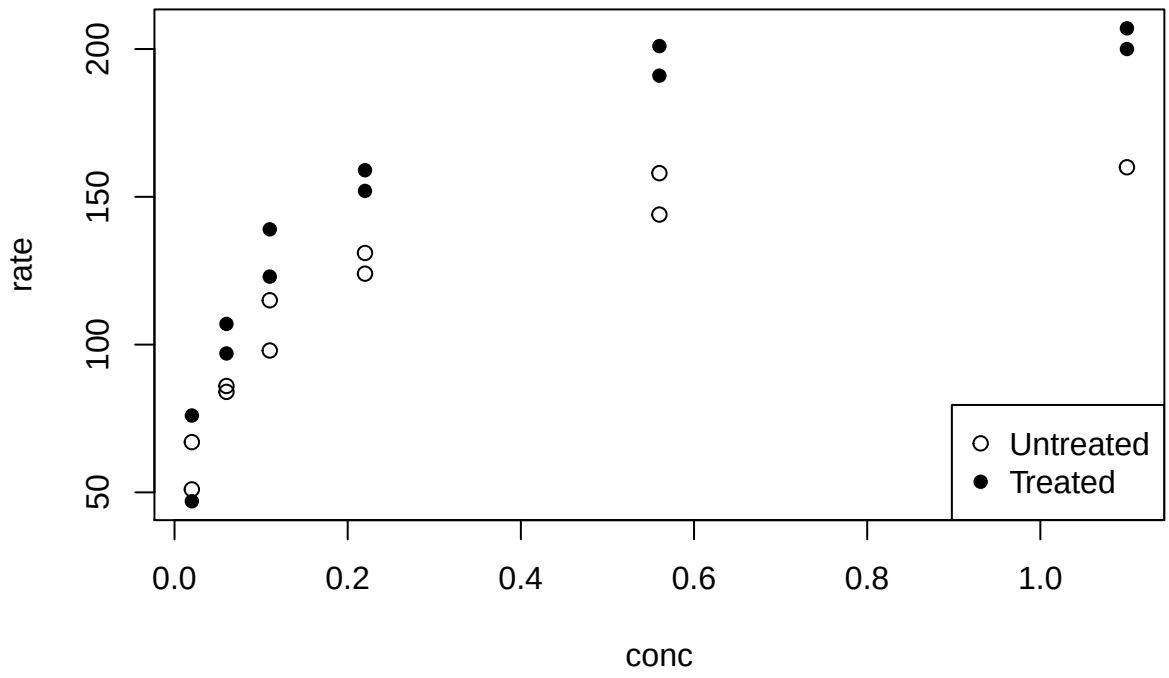
```
par(mfrow = c(2, 2))
boxplot(precip)
hist(precip)
plot.ecdf(precip)
qqnorm(precip)
```




```
par(mfrow = c(1, 1))
```

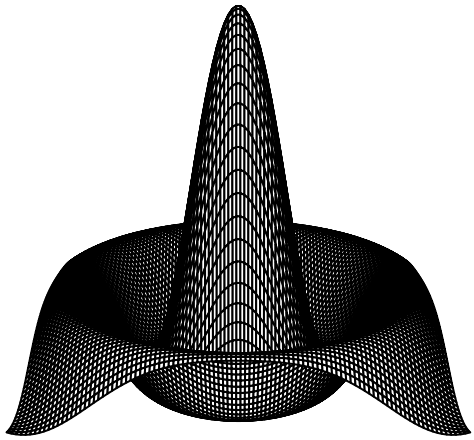
Plot using statistical model

```
plot(rate ~ conc, data = Puromycin, pch = 15 * (state == "treated") + 1)
legend("bottomright", legend = c("Untreated", "Treated"), pch = c(1, 16))
```

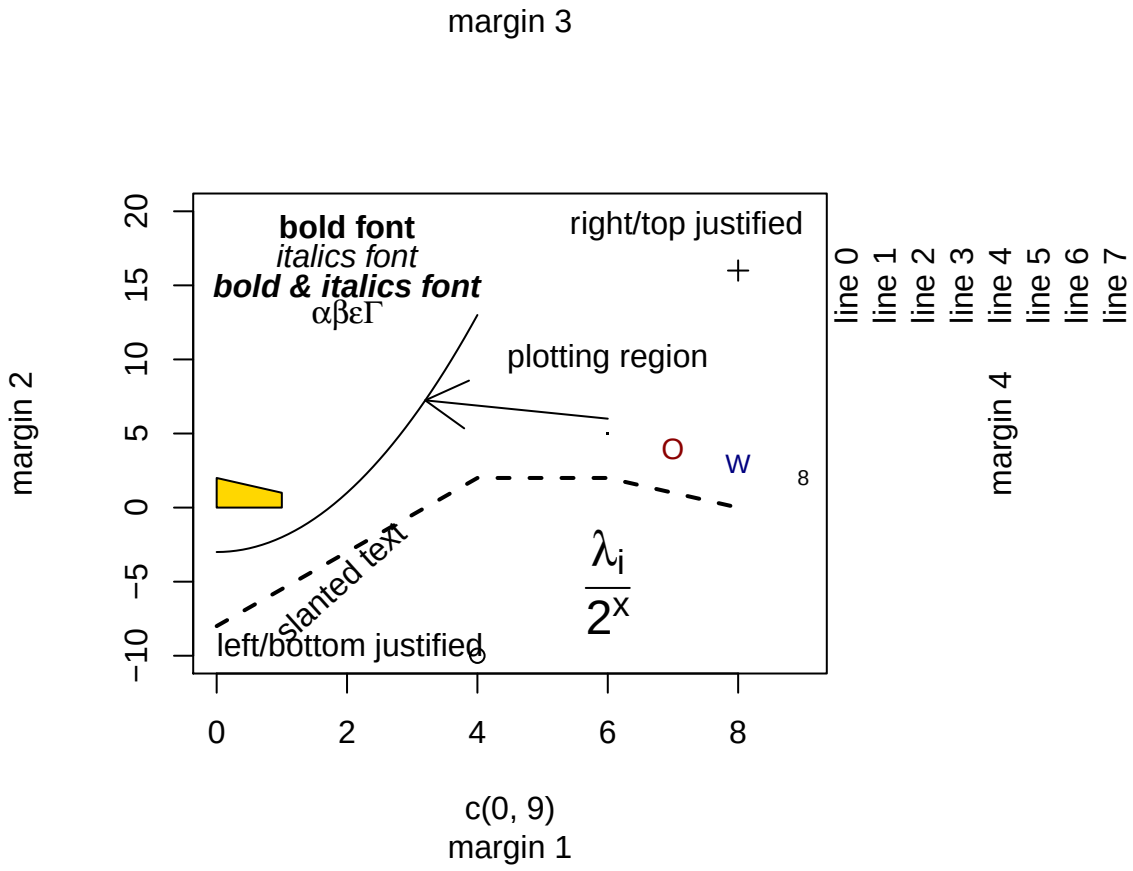


Plot using `persp()` for wire mesh

```
x <- seq(-8, 8, length = 100)
y <- x
f <- function(x, y) sin(sqrt(x ^ 2 + y ^ 2)) / (sqrt (x ^ 2 + y ^ 2))
z <- outer(x, y, f)
persp(x, y, z, xlab = "", ylab = "", zlab = "", axes = F, box = F)
```



Custom plot:


margin 3
bold font
italics font
bold & italics font
αβεΓ
right/top justified
plotting region
O
w
8
slanted text
left/bottom justified
$\frac{\lambda_i}{2^x}$
line 0
line 1
line 2
line 3
line 4
line 5
line 6
line 7
margin 4
margin 2
20
15
10
5
0
−5
−10
0
2
4
6
8
c(0, 9)
margin 1