mini_projects

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Preparing the data

```
# Save your input data file into your Project directory
fna.data <- "WisconsinCancer.csv"

# Complete the following code to input the data and store as wisc.df
wisc.df <- read.csv(fna.data, row.names=1)
head(wisc.df)
```

```
##          diagnosis radius_mean texture_mean perimeter_mean area_mean
## 842302           M       17.99        10.38         122.80    1001.0
## 842517           M       20.57        17.77         132.90    1326.0
## 84300903         M       19.69        21.25         130.00    1203.0
## 84348301         M       11.42        20.38          77.58     386.1
## 84358402         M       20.29        14.34         135.10    1297.0
## 843786           M       12.45        15.70          82.57     477.1
##          smoothness_mean compactness_mean concavity_mean concave.points_mean
## 842302           0.11840          0.27760         0.3001             0.14710
## 842517           0.08474          0.07864         0.0869             0.07017
## 84300903         0.10960          0.15990         0.1974             0.12790
## 84348301         0.14250          0.28390         0.2414             0.10520
## 84358402         0.10030          0.13280         0.1980             0.10430
## 843786           0.12780          0.17000         0.1578             0.08089
##          symmetry_mean fractal_dimension_mean radius_se texture_se perimeter_se
## 842302          0.2419                0.07871    1.0950     0.9053        8.589
## 842517          0.1812                0.05667    0.5435     0.7339        3.398
## 84300903        0.2069                0.05999    0.7456     0.7869        4.585
## 84348301        0.2597                0.09744    0.4956     1.1560        3.445
## 84358402        0.1809                0.05883    0.7572     0.7813        5.438
## 843786          0.2087                0.07613    0.3345     0.8902        2.217
##          area_se smoothness_se compactness_se concavity_se concave.points_se
## 842302    153.40      0.006399        0.04904      0.05373           0.01587
## 842517     74.08      0.005225        0.01308      0.01860           0.01340
## 84300903   94.03      0.006150        0.04006      0.03832           0.02058
## 84348301   27.23      0.009110        0.07458      0.05661           0.01867
## 84358402   94.44      0.011490        0.02461      0.05688           0.01885
## 843786     27.19      0.007510        0.03345      0.03672           0.01137
##          symmetry_se fractal_dimension_se radius_worst texture_worst
## 842302       0.03003             0.006193        25.38         17.33
## 842517       0.01389             0.003532        24.99         23.41
```

```
## 84300903     0.02250              0.004571        23.57          25.53
## 84348301     0.05963              0.009208        14.91          26.50
## 84358402     0.01756              0.005115        22.54          16.67
## 843786       0.02165              0.005082        15.47          23.75
##          perimeter_worst area_worst smoothness_worst compactness_worst
## 842302            184.60     2019.0           0.1622            0.6656
## 842517            158.80     1956.0           0.1238            0.1866
## 84300903          152.50     1709.0           0.1444            0.4245
## 84348301           98.87      567.7           0.2098            0.8663
## 84358402          152.20     1575.0           0.1374            0.2050
## 843786            103.40      741.6           0.1791            0.5249
##          concavity_worst concave.points_worst symmetry_worst
## 842302            0.7119               0.2654         0.4601
## 842517            0.2416               0.1860         0.2750
## 84300903          0.4504               0.2430         0.3613
## 84348301          0.6869               0.2575         0.6638
## 84358402          0.4000               0.1625         0.2364
## 843786            0.5355               0.1741         0.3985
##          fractal_dimension_worst
## 842302                   0.11890
## 842517                   0.08902
## 84300903                 0.08758
## 84348301                 0.17300
## 84358402                 0.07678
## 843786                   0.12440
```

```r
# We can use -1 here to remove the first column
wisc.data <- wisc.df[,-1]
```

```r
# Create diagnosis vector for later
diagnosis <- wisc.df$diagnosis
diagnosis
```

```
##   [1] "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M"
##  [19] "M" "B" "B" "B" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M"
##  [37] "M" "B" "M" "M" "M" "M" "M" "M" "M" "M" "B" "M" "B" "B" "B" "B" "B" "M"
##  [55] "M" "B" "M" "M" "B" "B" "B" "B" "M" "B" "M" "M" "B" "B" "B" "B" "M" "B"
##  [73] "M" "M" "B" "M" "B" "M" "M" "B" "B" "B" "M" "M" "B" "M" "M" "M" "B" "B"
##  [91] "B" "M" "B" "B" "M" "M" "B" "B" "B" "M" "M" "B" "B" "B" "B" "M" "B" "B"
## [109] "M" "B" "B" "B" "B" "B" "B" "B" "B" "M" "M" "M" "B" "M" "M" "B" "B" "B"
## [127] "M" "M" "B" "M" "B" "M" "M" "B" "M" "M" "B" "B" "M" "B" "B" "M" "B" "B"
## [145] "B" "B" "M" "B" "B" "B" "B" "B" "B" "B" "B" "B" "M" "B" "B" "B" "B" "M"
## [163] "M" "B" "M" "B" "B" "M" "M" "B" "B" "M" "M" "B" "B" "B" "B" "M" "B" "B"
## [181] "M" "M" "M" "B" "M" "B" "M" "B" "B" "B" "M" "B" "B" "M" "M" "B" "M" "M"
## [199] "M" "M" "B" "M" "M" "M" "B" "M" "B" "M" "B" "B" "M" "B" "M" "M" "M" "M"
## [217] "B" "B" "M" "M" "B" "B" "B" "M" "B" "B" "B" "B" "B" "M" "M" "B" "B" "M"
## [235] "B" "B" "M" "M" "B" "M" "B" "B" "B" "B" "M" "B" "B" "B" "B" "B" "M" "B"
## [253] "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "M" "B" "B" "B" "B"
## [271] "B" "B" "M" "B" "M" "B" "B" "M" "B" "B" "M" "B" "M" "M" "B" "B" "B" "B"
## [289] "B" "B" "B" "B" "B" "B" "B" "B" "B" "M" "B" "B" "M" "B" "M" "B" "B" "B"
## [307] "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "M" "B" "B" "B" "M" "B" "M"
## [325] "B" "B" "B" "B" "M" "M" "M" "B" "B" "B" "B" "M" "B" "M" "B" "M" "B" "B"
## [343] "B" "M" "B" "B" "B" "B" "B" "B" "B" "M" "M" "M" "B" "B" "B" "B" "B" "B"
```

```
## [361] "B" "B" "B" "B" "B" "M" "M" "B" "M" "M" "M" "B" "M" "M" "B" "B" "B" "B"
## [379] "B" "M" "B" "B" "B" "B" "B" "M" "B" "B" "B" "M" "B" "B" "M" "M" "B" "B"
## [397] "B" "B" "B" "B" "M" "B" "B" "B" "B" "B" "B" "B" "M" "B" "B" "B" "B" "B"
## [415] "M" "B" "B" "M" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "M" "B"
## [433] "M" "M" "B" "M" "B" "B" "B" "B" "B" "M" "B" "B" "M" "B" "M" "B" "B" "M"
## [451] "B" "M" "B" "B" "B" "B" "B" "B" "B" "B" "M" "M" "B" "B" "B" "B" "B" "B"
## [469] "M" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "M" "B" "B" "B" "B" "B" "B"
## [487] "B" "M" "B" "M" "B" "B" "M" "B" "B" "B" "B" "B" "M" "M" "B" "M" "B" "M"
## [505] "B" "B" "B" "B" "B" "M" "B" "B" "M" "B" "M" "B" "M" "M" "B" "B" "B" "M"
## [523] "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "M" "B" "M" "M" "B" "B" "B"
## [541] "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B" "B"
## [559] "B" "B" "B" "B" "M" "M" "M" "M" "M" "M" "B"
```

Exploratory data analysis

Q1. How many observations are in this dataset?

```
dim(wisc.data)
```

```
## [1] 569  30
```

```
nrow(wisc.data)
```

```
## [1] 569
```

```
#there are 569 observations in the data set
```

Q2. How many of the observations have a malignant diagnosis?

```
#use the table function to count the number of benign and malignant diagnosis
table (diagnosis)
```

```
## diagnosis
##   B   M
## 357 212
```

```
#There are 212 malignant diagnosis
```

Q3. How many variables/features in the data are suffixed with _mean?

```
#Check the variables in the data
colnames(wisc.df)
```

```
##  [1] "diagnosis"               "radius_mean"
##  [3] "texture_mean"            "perimeter_mean"
##  [5] "area_mean"               "smoothness_mean"
##  [7] "compactness_mean"        "concavity_mean"
##  [9] "concave.points_mean"     "symmetry_mean"
## [11] "fractal_dimension_mean"  "radius_se"
```

```
## [13] "texture_se"              "perimeter_se"
## [15] "area_se"                 "smoothness_se"
## [17] "compactness_se"          "concavity_se"
## [19] "concave.points_se"       "symmetry_se"
## [21] "fractal_dimension_se"    "radius_worst"
## [23] "texture_worst"           "perimeter_worst"
## [25] "area_worst"              "smoothness_worst"
## [27] "compactness_worst"       "concavity_worst"
## [29] "concave.points_worst"    "symmetry_worst"
## [31] "fractal_dimension_worst"
```

```
#Use grep to create a vector that has a count of the column names with "_mean"
#Use length to count the vector created by grep
length(grep("_mean",colnames(wisc.df)))
```

```
## [1] 10
```

```
#there are 10 variables int eh data that are suffixed with "_mean"
```

Performing PCA

```
# Check column means and standard deviations
colMeans(wisc.data)
```

```
##             radius_mean            texture_mean          perimeter_mean
##            1.412729e+01            1.928965e+01            9.196903e+01
##               area_mean         smoothness_mean        compactness_mean
##            6.548891e+02            9.636028e-02            1.043410e-01
##          concavity_mean     concave.points_mean           symmetry_mean
##            8.879932e-02            4.891915e-02            1.811619e-01
##  fractal_dimension_mean               radius_se              texture_se
##            6.279761e-02            4.051721e-01            1.216853e+00
##            perimeter_se                 area_se           smoothness_se
##            2.866059e+00            4.033708e+01            7.040979e-03
##          compactness_se            concavity_se       concave.points_se
##            2.547814e-02            3.189372e-02            1.179614e-02
##             symmetry_se    fractal_dimension_se            radius_worst
##            2.054230e-02            3.794904e-03            1.626919e+01
##           texture_worst         perimeter_worst              area_worst
##            2.567722e+01            1.072612e+02            8.805831e+02
##        smoothness_worst       compactness_worst         concavity_worst
##            1.323686e-01            2.542650e-01            2.721885e-01
##    concave.points_worst          symmetry_worst fractal_dimension_worst
##            1.146062e-01            2.900756e-01            8.394582e-02
```

```
apply(wisc.data,2,sd)
```

```
##             radius_mean            texture_mean          perimeter_mean
##            3.524049e+00            4.301036e+00            2.429898e+01
##               area_mean         smoothness_mean        compactness_mean
```

```
##            3.519141e+02            1.406413e-02            5.281276e-02
##          concavity_mean     concave.points_mean           symmetry_mean
##            7.971981e-02            3.880284e-02            2.741428e-02
##  fractal_dimension_mean               radius_se              texture_se
##            7.060363e-03            2.773127e-01            5.516484e-01
##            perimeter_se                 area_se           smoothness_se
##            2.021855e+00            4.549101e+01            3.002518e-03
##          compactness_se            concavity_se       concave.points_se
##            1.790818e-02            3.018606e-02            6.170285e-03
##             symmetry_se    fractal_dimension_se            radius_worst
##            8.266372e-03            2.646071e-03            4.833242e+00
##           texture_worst         perimeter_worst              area_worst
##            6.146258e+00            3.360254e+01            5.693570e+02
##        smoothness_worst       compactness_worst         concavity_worst
##            2.283243e-02            1.573365e-01            2.086243e-01
##    concave.points_worst          symmetry_worst fractal_dimension_worst
##            6.573234e-02            6.186747e-02            1.806127e-02
```

```
# Perform PCA on wisc.data by completing the following code
wisc.pr <- prcomp( wisc.data, scale=TRUE )
wisc.pr
```

```
## Standard deviations (1, .., p=30):
##  [1] 3.64439401 2.38565601 1.67867477 1.40735229 1.28402903 1.09879780
##  [7] 0.82171778 0.69037464 0.64567392 0.59219377 0.54213992 0.51103950
## [13] 0.49128148 0.39624453 0.30681422 0.28260007 0.24371918 0.22938785
## [19] 0.22243559 0.17652026 0.17312681 0.16564843 0.15601550 0.13436892
## [25] 0.12442376 0.09043030 0.08306903 0.03986650 0.02736427 0.01153451
##
## Rotation (n x k) = (30 x 30):
##                                PC1          PC2          PC3          PC4
## radius_mean             -0.21890244  0.233857132 -0.008531243  0.041408962
## texture_mean            -0.10372458  0.059706088  0.064549903 -0.603050001
## perimeter_mean          -0.22753729  0.215181361 -0.009314220  0.041983099
## area_mean               -0.22099499  0.231076711  0.028699526  0.053433795
## smoothness_mean         -0.14258969 -0.186113023 -0.104291904  0.159382765
## compactness_mean        -0.23928535 -0.151891610 -0.074091571  0.031794581
## concavity_mean          -0.25840048 -0.060165363  0.002733838  0.019122753
## concave.points_mean     -0.26085376  0.034767500 -0.025563541  0.065335944
## symmetry_mean           -0.13816696 -0.190348770 -0.040239936  0.067124984
## fractal_dimension_mean  -0.06436335 -0.366575471 -0.022574090  0.048586765
## radius_se               -0.20597878  0.105552152  0.268481387  0.097941242
## texture_se              -0.01742803 -0.089979682  0.374633665 -0.359855528
## perimeter_se            -0.21132592  0.089457234  0.266645367  0.088992415
## area_se                 -0.20286964  0.152292628  0.216006528  0.108205039
## smoothness_se           -0.01453145 -0.204430453  0.308838979  0.044664180
## compactness_se          -0.17039345 -0.232715896  0.154779718 -0.027469363
## concavity_se            -0.15358979 -0.197207283  0.176463743  0.001316880
## concave.points_se       -0.18341740 -0.130321560  0.224657567  0.074067335
## symmetry_se             -0.04249842 -0.183848000  0.288584292  0.044073351
## fractal_dimension_se    -0.10256832 -0.280092027  0.211503764  0.015304750
## radius_worst            -0.22799663  0.219866379 -0.047506990  0.015417240
## texture_worst           -0.10446933  0.045467298 -0.042297823 -0.632807885
## perimeter_worst         -0.23663968  0.199878428 -0.048546508  0.013802794
```

```
## area_worst              -0.22487053  0.219351858 -0.011902318  0.025894749
## smoothness_worst        -0.12795256 -0.172304352 -0.259797613  0.017652216
## compactness_worst       -0.21009588 -0.143593173 -0.236075625 -0.091328415
## concavity_worst         -0.22876753 -0.097964114 -0.173057335 -0.073951180
## concave.points_worst    -0.25088597  0.008257235 -0.170344076  0.006006996
## symmetry_worst          -0.12290456 -0.141883349 -0.271312642 -0.036250695
## fractal_dimension_worst -0.13178394 -0.275339469 -0.232791313 -0.077053470
##                                  PC5           PC6           PC7          PC8
## radius_mean             -0.037786354  0.0187407904 -0.1240883403  0.007452296
## texture_mean             0.049468850 -0.0321788366  0.0113995382 -0.130674825
## perimeter_mean          -0.037374663  0.0173084449 -0.1144770573  0.018687258
## area_mean               -0.010331251 -0.0018877480 -0.0516534275 -0.034673604
## smoothness_mean          0.365088528 -0.2863744966 -0.1406689928  0.288974575
## compactness_mean        -0.011703971 -0.0141309489  0.0309184960  0.151396350
## concavity_mean          -0.086375412 -0.0093441809 -0.1075204434  0.072827285
## concave.points_mean      0.043861025 -0.0520499505 -0.1504822142  0.152322414
## symmetry_mean            0.305941428  0.3564584607 -0.0938911345  0.231530989
## fractal_dimension_mean   0.044424360 -0.1194306679  0.2957600240  0.177121441
## radius_se                0.154456496 -0.0256032561  0.3124900373 -0.022539967
## texture_se               0.191650506 -0.0287473145 -0.0907553556  0.475413139
## perimeter_se             0.120990220  0.0018107150  0.3146403902  0.011896690
## area_se                  0.127574432 -0.0428639079  0.3466790028 -0.085805135
## smoothness_se            0.232065676 -0.3429173935 -0.2440240556 -0.573410232
## compactness_se          -0.279968156  0.0691975186  0.0234635340 -0.117460157
## concavity_se            -0.353982091  0.0563432386 -0.2088237897 -0.060566501
## concave.points_se       -0.195548089 -0.0312244482 -0.3696459369  0.108319309
## symmetry_se              0.252868765  0.4902456426 -0.0803822539 -0.220149279
## fractal_dimension_se    -0.263297438 -0.0531952674  0.1913949726 -0.011168188
## radius_worst             0.004406592 -0.0002906849 -0.0097099360 -0.042619416
## texture_worst            0.092883400 -0.0500080613  0.0098707439 -0.036251636
## perimeter_worst         -0.007454151  0.0085009872 -0.0004457267 -0.030558534
## area_worst               0.027390903 -0.0251643821  0.0678316595 -0.079394246
## smoothness_worst         0.324435445 -0.3692553703 -0.1088308865 -0.205852191
## compactness_worst       -0.121804107  0.0477057929  0.1404729381 -0.084019659
## concavity_worst         -0.188518727  0.0283792555 -0.0604880561 -0.072467871
## concave.points_worst    -0.043332069 -0.0308734498 -0.1679666187  0.036170795
## symmetry_worst           0.244558663  0.4989267845 -0.0184906298 -0.228225053
## fractal_dimension_worst -0.094423351 -0.0802235245  0.3746576261 -0.048360667
##                                  PC9         PC10        PC11         PC12
## radius_mean             -0.223109764  0.095486443 -0.04147149  0.051067457
## texture_mean             0.112699390  0.240934066  0.30224340  0.254896423
## perimeter_mean          -0.223739213  0.086385615 -0.01678264  0.038926106
## area_mean               -0.195586014  0.074956489 -0.11016964  0.065437508
## smoothness_mean          0.006424722 -0.069292681  0.13702184  0.316727211
## compactness_mean        -0.167841425  0.012936200  0.30800963 -0.104017044
## concavity_mean           0.040591006 -0.135602298 -0.12419024  0.065653480
## concave.points_mean     -0.111971106  0.008054528  0.07244603  0.042589267
## symmetry_mean            0.256040084  0.572069479 -0.16305408 -0.288865504
## fractal_dimension_mean  -0.123740789  0.081103207  0.03804827  0.236358988
## radius_se                0.249985002 -0.049547594  0.02535702 -0.016687915
## texture_se              -0.246645397 -0.289142742 -0.34494446 -0.306160423
## perimeter_se             0.227154024 -0.114508236  0.16731877 -0.101446828
## area_se                  0.229160015 -0.091927889 -0.05161946 -0.017679218
## smoothness_se           -0.141924890  0.160884609 -0.08420621 -0.294710053
```

```
## compactness_se         -0.145322810  0.043504866  0.20688568 -0.263456509
## concavity_se            0.358107079 -0.141276243 -0.34951794  0.251146975
## concave.points_se       0.272519886  0.086240847  0.34237591 -0.006458751
## symmetry_se            -0.304077200 -0.316529830  0.18784404  0.320571348
## fractal_dimension_se   -0.213722716  0.367541918 -0.25062479  0.276165974
## radius_worst           -0.112141463  0.077361643 -0.10506733  0.039679665
## texture_worst           0.103341204  0.029550941 -0.01315727  0.079797450
## perimeter_worst        -0.109614364  0.050508334 -0.05107628 -0.008987738
## area_worst             -0.080732461  0.069921152 -0.18459894  0.048088657
## smoothness_worst        0.112315904 -0.128304659 -0.14389035  0.056514866
## compactness_worst      -0.100677822 -0.172133632  0.19742047 -0.371662503
## concavity_worst         0.161908621 -0.311638520 -0.18501676 -0.087034532
## concave.points_worst    0.060488462 -0.076648291  0.11777205 -0.068125354
## symmetry_worst          0.064637806 -0.029563075 -0.15756025  0.044033503
## fractal_dimension_worst -0.134174175  0.012609579 -0.11828355 -0.034731693
##                                PC13         PC14         PC15        PC16
## radius_mean             0.01196721  0.059506135 -0.051118775 -0.15058388
## texture_mean            0.20346133 -0.021560100 -0.107922421 -0.15784196
## perimeter_mean          0.04410950  0.048513812 -0.039902936 -0.11445396
## area_mean               0.06737574  0.010830829  0.013966907 -0.13244803
## smoothness_mean         0.04557360  0.445064860 -0.118143364 -0.20461325
## compactness_mean        0.22928130  0.008101057  0.230899962  0.17017837
## concavity_mean          0.38709081 -0.189358699 -0.128283732  0.26947021
## concave.points_mean     0.13213810 -0.244794768 -0.217099194  0.38046410
## symmetry_mean           0.18993367  0.030738856 -0.073961707 -0.16466159
## fractal_dimension_mean  0.10623908 -0.377078865  0.517975705 -0.04079279
## radius_se              -0.06819523  0.010347413 -0.110050711  0.05890572
## texture_se             -0.16822238 -0.010849347  0.032752721 -0.03450040
## perimeter_se           -0.03784399 -0.045523718 -0.008268089  0.02651665
## area_se                 0.05606493  0.083570718 -0.046024366  0.04115323
## smoothness_se           0.15044143 -0.201152530  0.018559465 -0.05803906
## compactness_se          0.01004017  0.491755932  0.168209315  0.18983090
## concavity_se            0.15878319  0.134586924  0.250471408 -0.12542065
## concave.points_se      -0.49402674 -0.199666719  0.062079344 -0.19881035
## symmetry_se             0.01033274 -0.046864383 -0.113383199 -0.15771150
## fractal_dimension_se   -0.24045832  0.145652466 -0.353232211  0.26855388
## radius_worst           -0.13789053  0.023101281  0.166567074 -0.08156057
## texture_worst          -0.08014543  0.053430792  0.101115399  0.18555785
## perimeter_worst        -0.09696571  0.012219382  0.182755198 -0.05485705
## area_worst             -0.10116061 -0.006685465  0.314993600 -0.09065339
## smoothness_worst       -0.20513034  0.162235443  0.046125866  0.14555166
## compactness_worst       0.01227931  0.166470250 -0.049956014 -0.15373486
## concavity_worst         0.21798433 -0.066798931 -0.204835886 -0.21502195
## concave.points_worst   -0.25438749 -0.276418891 -0.169499607  0.17814174
## symmetry_worst         -0.25653491  0.005355574  0.139888394  0.25789401
## fractal_dimension_worst -0.17281424 -0.212104110 -0.256173195 -0.40555649
##                                 PC17          PC18        PC19         PC20
## radius_mean             0.202924255  0.1467123385  0.22538466 -0.049698664
## texture_mean           -0.038706119 -0.0411029851  0.02978864 -0.244134993
## perimeter_mean          0.194821310  0.1583174548  0.23959528 -0.017665012
## area_mean               0.255705763  0.2661681046 -0.02732219 -0.090143762
## smoothness_mean         0.167929914 -0.3522268017 -0.16456584  0.017100960
## compactness_mean       -0.020307708  0.0077941384  0.28422236  0.488686329
## concavity_mean         -0.001598353 -0.0269681105  0.00226636 -0.033387086
```

```
## concave.points_mean      0.034509509 -0.0828277367 -0.15497236 -0.235407606
## symmetry_mean           -0.191737848  0.1733977905 -0.05881116  0.026069156
## fractal_dimension_mean   0.050225246  0.0878673570 -0.05815705 -0.175637222
## radius_se               -0.139396866 -0.2362165319  0.17588331 -0.090800503
## texture_se               0.043963016 -0.0098586620  0.03600985 -0.071659988
## perimeter_se            -0.024635639 -0.0259288003  0.36570154 -0.177250625
## area_se                  0.334418173  0.3049069032 -0.41657231  0.274201148
## smoothness_se            0.139595006 -0.2312599432 -0.01326009  0.090061477
## compactness_se          -0.008246477  0.1004742346 -0.24244818 -0.461098220
## concavity_se             0.084616716 -0.0001954852  0.12638102  0.066946174
## concave.points_se        0.108132263  0.0460549116 -0.01216430  0.068868294
## symmetry_se             -0.274059129  0.1870147640 -0.08903929  0.107385289
## fractal_dimension_se    -0.122733398 -0.0598230982  0.08660084  0.222345297
## radius_worst            -0.240049982 -0.2161013526  0.01366130 -0.005626909
## texture_worst            0.069365185  0.0583984505 -0.07586693  0.300599798
## perimeter_worst         -0.234164147 -0.1885435919  0.09081325  0.011003858
## area_worst              -0.273399584 -0.1420648558 -0.41004720  0.060047387
## smoothness_worst        -0.278030197  0.5015516751  0.23451384 -0.129723903
## compactness_worst       -0.004037123 -0.0735745143  0.02020070  0.229280589
## concavity_worst         -0.191313419 -0.1039079796 -0.04578612 -0.046482792
## concave.points_worst    -0.075485316  0.0758138963 -0.26022962  0.033022340
## symmetry_worst           0.430658116 -0.2787138431  0.11725053 -0.116759236
## fractal_dimension_worst  0.159394300  0.0235647497 -0.01149448 -0.104991974
##                                  PC21        PC22          PC23        PC24
## radius_mean             -0.0685700057 -0.07292890 -0.0985526942 -0.18257944
## texture_mean             0.4483694667 -0.09480063 -0.0005549975  0.09878679
## perimeter_mean          -0.0697690429 -0.07516048 -0.0402447050 -0.11664888
## area_mean               -0.0184432785 -0.09756578  0.0077772734  0.06984834
## smoothness_mean         -0.1194917473 -0.06382295 -0.0206657211  0.06869742
## compactness_mean         0.1926213963  0.09807756  0.0523603957 -0.10413552
## concavity_mean           0.0055717533  0.18521200  0.3248703785  0.04474106
## concave.points_mean     -0.0094238187  0.31185243 -0.0514087968  0.08402770
## symmetry_mean           -0.0869384844  0.01840673 -0.0512005770  0.01933947
## fractal_dimension_mean  -0.0762718362 -0.28786888 -0.0846898562 -0.13326055
## radius_se                0.0863867747  0.15027468 -0.2641253170 -0.55870157
## texture_se               0.2170719674 -0.04845693 -0.0008738805  0.02426730
## perimeter_se            -0.3049501584 -0.15935280  0.0900742110  0.51675039
## area_se                  0.1925877857 -0.06423262  0.0982150746 -0.02246072
## smoothness_se           -0.0720987261 -0.05054490 -0.0598177179  0.01563119
## compactness_se          -0.1403865724  0.04528769  0.0091038710 -0.12177779
## concavity_se             0.0630479298  0.20521269 -0.3875423290  0.18820504
## concave.points_se        0.0343753236  0.07254538  0.3517550738 -0.10966898
## symmetry_se             -0.0976995265  0.08465443 -0.0423628949  0.00322620
## fractal_dimension_se     0.0628432814 -0.24470508  0.0857810992  0.07519442
## radius_worst             0.0072938995  0.09629821 -0.0556767923 -0.15683037
## texture_worst           -0.5944401434  0.11111202 -0.0089228997 -0.11848460
## perimeter_worst         -0.0920235990 -0.01722163  0.0633448296  0.23711317
## area_worst               0.1467901315  0.09695982  0.1908896250  0.14406303
## smoothness_worst         0.1648492374  0.06825409  0.0936901494 -0.01099014
## compactness_worst        0.1813748671 -0.02967641 -0.1479209247  0.18674995
## concavity_worst         -0.1321005945 -0.46042619  0.2864331353 -0.28885257
## concave.points_worst     0.0008860815 -0.29984056 -0.5675277966  0.10734024
## symmetry_worst           0.1627085487 -0.09714484  0.1213434508 -0.01438181
## fractal_dimension_worst -0.0923439434  0.46947115  0.0076253382  0.03782545
```

```
##                                PC25        PC26         PC27          PC28
## radius_mean             -0.01922650 -0.129476396 -0.131526670  2.111940e-01
## texture_mean             0.08474593 -0.024556664 -0.017357309 -6.581146e-05
## perimeter_mean           0.02701541 -0.125255946 -0.115415423  8.433827e-02
## area_mean               -0.21004078  0.362727403  0.466612477 -2.725083e-01
## smoothness_mean          0.02895489 -0.037003686  0.069689923  1.479269e-03
## compactness_mean         0.39662323  0.262808474  0.097748705 -5.462767e-03
## concavity_mean          -0.09697732 -0.548876170  0.364808397  4.553864e-02
## concave.points_mean     -0.18645160  0.387643377 -0.454699351 -8.883097e-03
## symmetry_mean           -0.02458369 -0.016044038 -0.015164835  1.433026e-03
## fractal_dimension_mean  -0.20722186 -0.097404839 -0.101244946 -6.311687e-03
## radius_se               -0.17493043  0.049977080  0.212982901 -1.922239e-01
## texture_se               0.05698648 -0.011237242 -0.010092889 -5.622611e-03
## perimeter_se             0.07292764  0.103653282  0.041691553  2.631919e-01
## area_se                  0.13185041 -0.155304589 -0.313358657 -4.206811e-02
## smoothness_se            0.03121070 -0.007717557 -0.009052154  9.792963e-03
## compactness_se           0.17316455 -0.049727632  0.046536088 -1.539555e-02
## concavity_se             0.01593998  0.091454968 -0.084224797  5.820978e-03
## concave.points_se       -0.12954655 -0.017941919 -0.011165509 -2.900930e-02
## symmetry_se             -0.01951493 -0.017267849 -0.019975983 -7.636526e-03
## fractal_dimension_se    -0.08417120  0.035488974 -0.012036564  1.975646e-02
## radius_worst             0.07070972 -0.197054744 -0.178666740  4.126396e-01
## texture_worst           -0.11818972  0.036469433  0.021410694 -3.902509e-04
## perimeter_worst          0.11803403 -0.244103670 -0.241031046 -7.286809e-01
## area_worst              -0.03828995  0.231359525  0.237162466  2.389603e-01
## smoothness_worst        -0.04796476  0.012602464 -0.040853568 -1.535248e-03
## compactness_worst       -0.62438494 -0.100463424 -0.070505414  4.869182e-02
## concavity_worst          0.11577034  0.266853781 -0.142905801 -1.764090e-02
## concave.points_worst     0.26319634 -0.133574507  0.230901389  2.247567e-02
## symmetry_worst           0.04529962  0.028184296  0.022790444  4.920481e-03
## fractal_dimension_worst  0.28013348  0.004520482  0.059985998 -2.356214e-02
##                                  PC29          PC30
## radius_mean              2.114605e-01  0.7024140910
## texture_mean            -1.053393e-02  0.0002736610
## perimeter_mean           3.838261e-01 -0.6898969685
## area_mean               -4.227949e-01 -0.0329473482
## smoothness_mean         -3.434667e-03 -0.0048474577
## compactness_mean        -4.101677e-02  0.0446741863
## concavity_mean          -1.001479e-02  0.0251386661
## concave.points_mean     -4.206949e-03 -0.0010772653
## symmetry_mean           -7.569862e-03 -0.0012803794
## fractal_dimension_mean   7.301433e-03 -0.0047556848
## radius_se                1.184421e-01 -0.0087110937
## texture_se              -8.776279e-03 -0.0010710392
## perimeter_se            -6.100219e-03  0.0137293906
## area_se                 -8.592591e-02  0.0011053260
## smoothness_se            1.776386e-03 -0.0016082109
## compactness_se           3.158134e-03  0.0019156224
## concavity_se             1.607852e-02 -0.0089265265
## concave.points_se       -2.393779e-02 -0.0021601973
## symmetry_se             -5.223292e-03  0.0003293898
## fractal_dimension_se    -8.341912e-03  0.0017989568
## radius_worst            -6.357249e-01 -0.1356430561
## texture_worst            1.723549e-02  0.0010205360
```

```
## perimeter_worst          2.292180e-02  0.0797438536
## area_worst               4.449359e-01  0.0397422838
## smoothness_worst         7.385492e-03  0.0045832773
## compactness_worst        3.566904e-06 -0.0128415624
## concavity_worst         -1.267572e-02  0.0004021392
## concave.points_worst     3.524045e-02 -0.0022884418
## symmetry_worst           1.340423e-02  0.0003954435
## fractal_dimension_worst  1.147766e-02  0.0018942925
```

```
# Look at summary of results
summary(wisc.pr)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     3.6444 2.3857 1.67867 1.40735 1.28403 1.09880 0.82172
## Proportion of Variance 0.4427 0.1897 0.09393 0.06602 0.05496 0.04025 0.02251
## Cumulative Proportion  0.4427 0.6324 0.72636 0.79239 0.84734 0.88759 0.91010
##                            PC8    PC9    PC10   PC11    PC12    PC13    PC14
## Standard deviation     0.69037 0.6457 0.59219 0.5421 0.51104 0.49128 0.39624
## Proportion of Variance 0.01589 0.0139 0.01169 0.0098 0.00871 0.00805 0.00523
## Cumulative Proportion  0.92598 0.9399 0.95157 0.9614 0.97007 0.97812 0.98335
##                           PC15    PC16    PC17    PC18    PC19    PC20   PC21
## Standard deviation     0.30681 0.28260 0.24372 0.22939 0.22244 0.17652 0.1731
## Proportion of Variance 0.00314 0.00266 0.00198 0.00175 0.00165 0.00104 0.0010
## Cumulative Proportion  0.98649 0.98915 0.99113 0.99288 0.99453 0.99557 0.9966
##                           PC22    PC23   PC24    PC25    PC26    PC27    PC28
## Standard deviation     0.16565 0.15602 0.1344 0.12442 0.09043 0.08307 0.03987
## Proportion of Variance 0.00091 0.00081 0.0006 0.00052 0.00027 0.00023 0.00005
## Cumulative Proportion  0.99749 0.99830 0.9989 0.99942 0.99969 0.99992 0.99997
##                           PC29    PC30
## Standard deviation     0.02736 0.01153
## Proportion of Variance 0.00002 0.00000
## Cumulative Proportion  1.00000 1.00000
```

> Q4. From your results, what proportion of the original variance is captured by the first principal components (PC1)?

- 0.4427 of the original variance is camptured by the first principal compoents (PC1)

> Q5. How many principal components (PCs) are required to describe at least 70% of the original variance in the data?

- 3 components describe at least 70% or the original variance in the data

> Q6. How many principal components (PCs) are required to describe at least 90% of the original variance in the data?

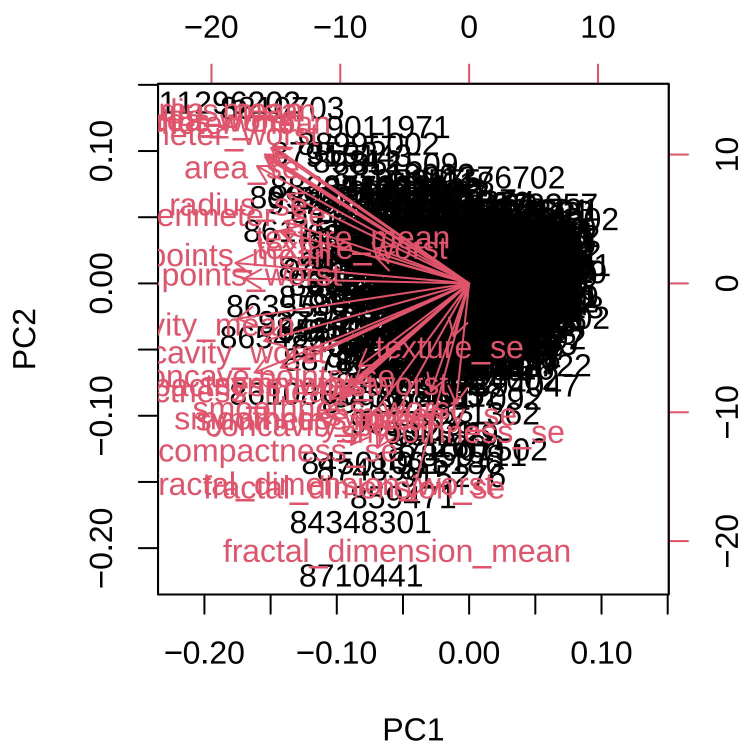
- 7 components describe at least 90% of the original variance in the data

Interpreting PCA results

> Q7. What stands out to you about this plot? Is it easy or difficult to understand? Why?

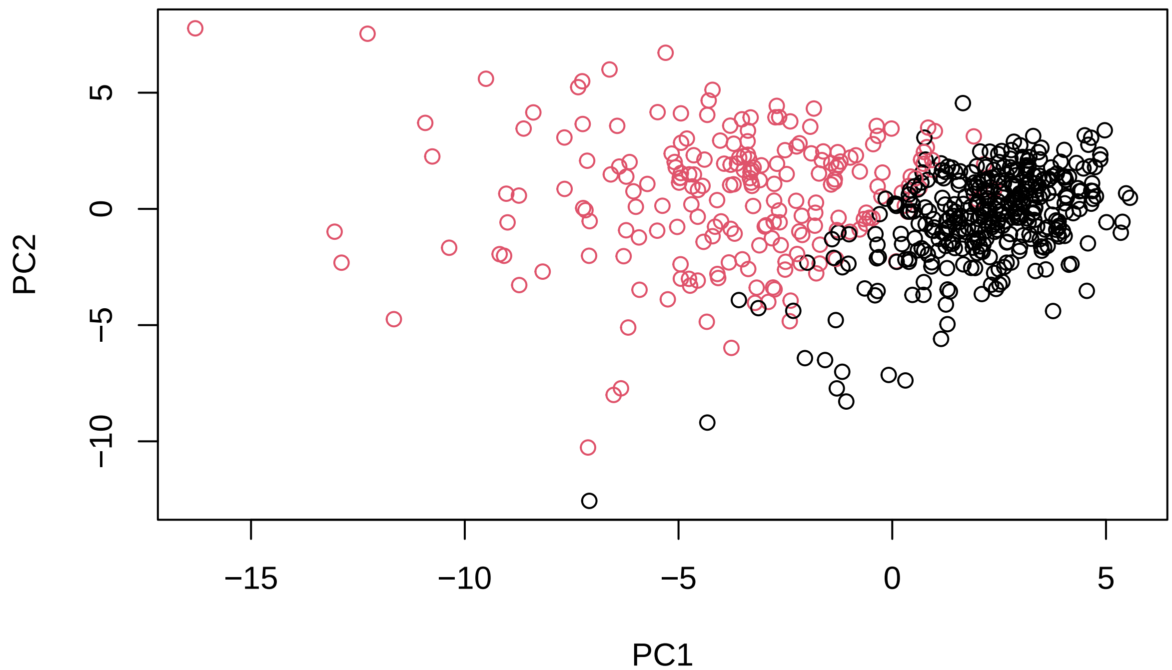
- This plot is messy and difficult to interpret because it uses rownames as the plotting character for biplots

```r
#Create a biplot of the wisc.pr using the biplot() function
biplot(wisc.pr)
```



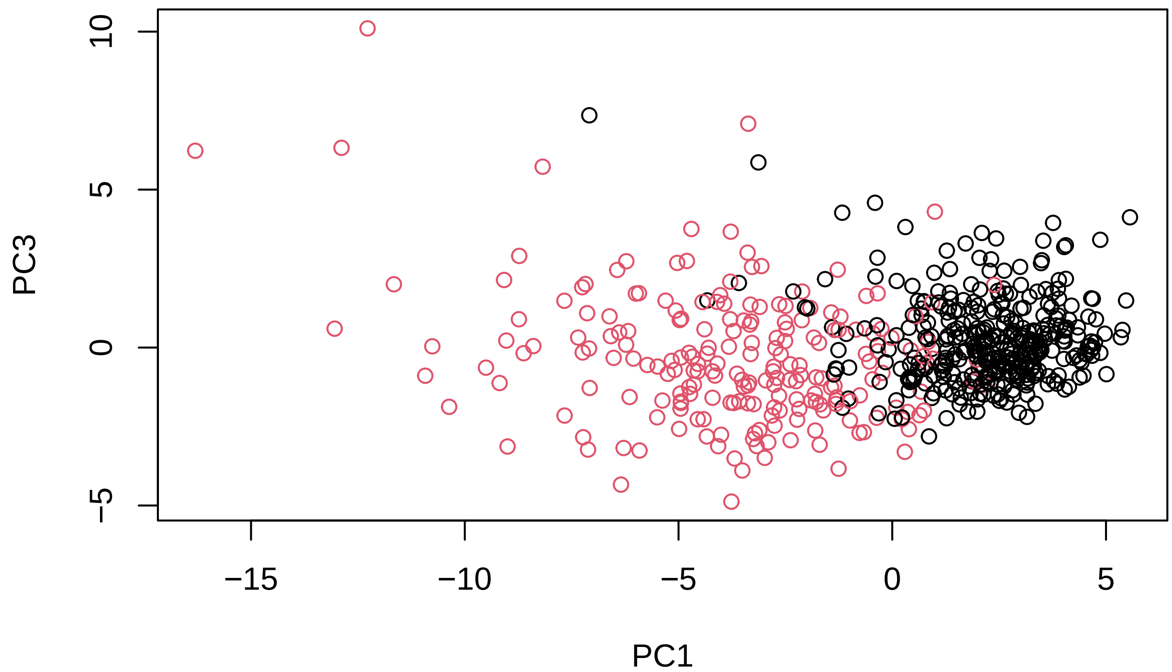

```r
#Scatter plot observations by components 1 and 2
#we need to access the pca scores data using wisc.pr$x
#pc1 and pc2 are in [,1:2]
#use as.factor to make diagnosis a binary to differentiate colors

plot(wisc.pr$x[,1:2], col=as.factor(diagnosis), xlab = "PC1", ylab = "PC2")
```



Q8. Generate a similar plot for principal components 1 and 3. What do you notice about these plots?

```
plot(wisc.pr$x[,1], wisc.pr$x[,3], col=as.factor(diagnosis), xlab = "PC1", ylab = "PC3")
```



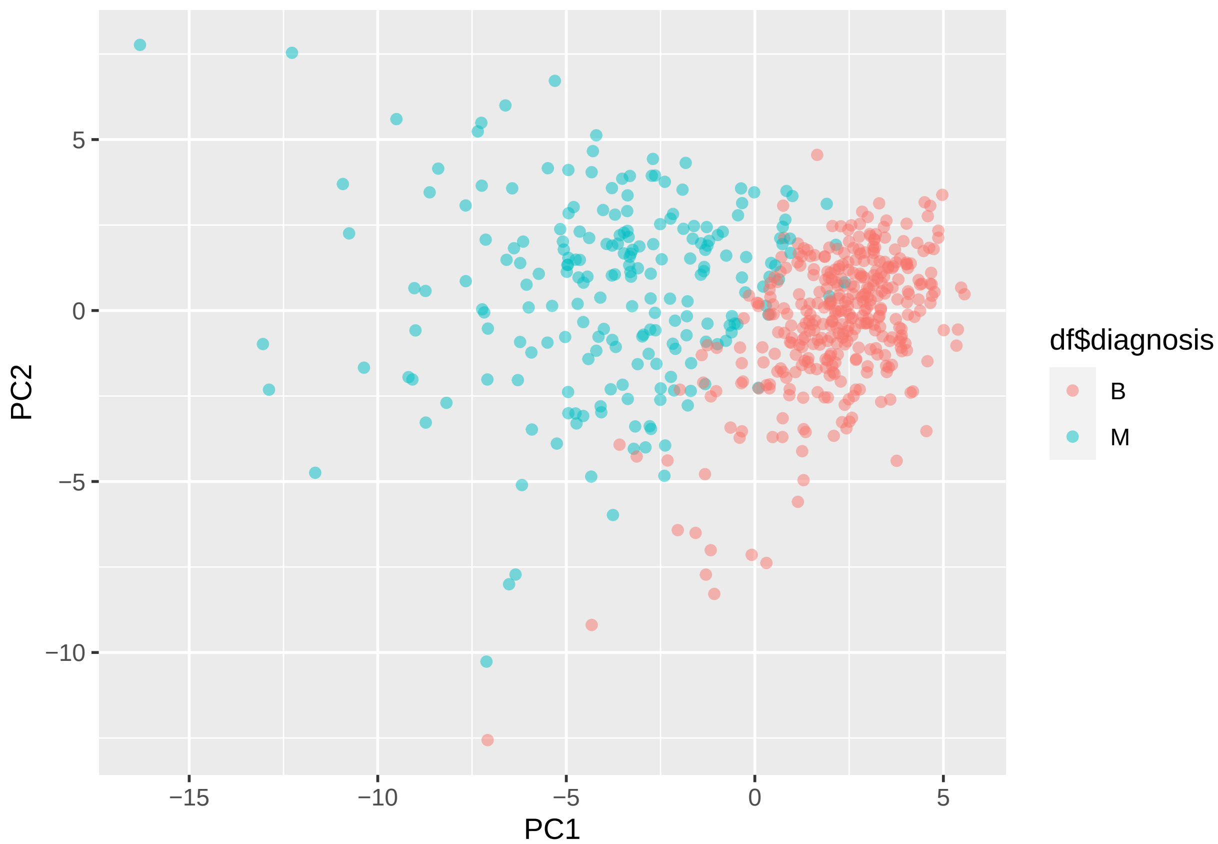
- the component 2 explains more variance in the original data than component 3. The first plot has a cleaner seperation between the two subgroups.

```
# Create a data.frame for ggplot
df <- as.data.frame(wisc.pr$x)
df$diagnosis <- diagnosis

# Load the ggplot2 package
library(ggplot2)

# Make a scatter plot colored by diagnosis
ggplot(df) +
  aes(PC1, PC2, color=df$diagnosis) +
  geom_point(alpha=0.5)
```

```
## Warning: Use of `df$diagnosis` is discouraged. Use `diagnosis` instead.
```



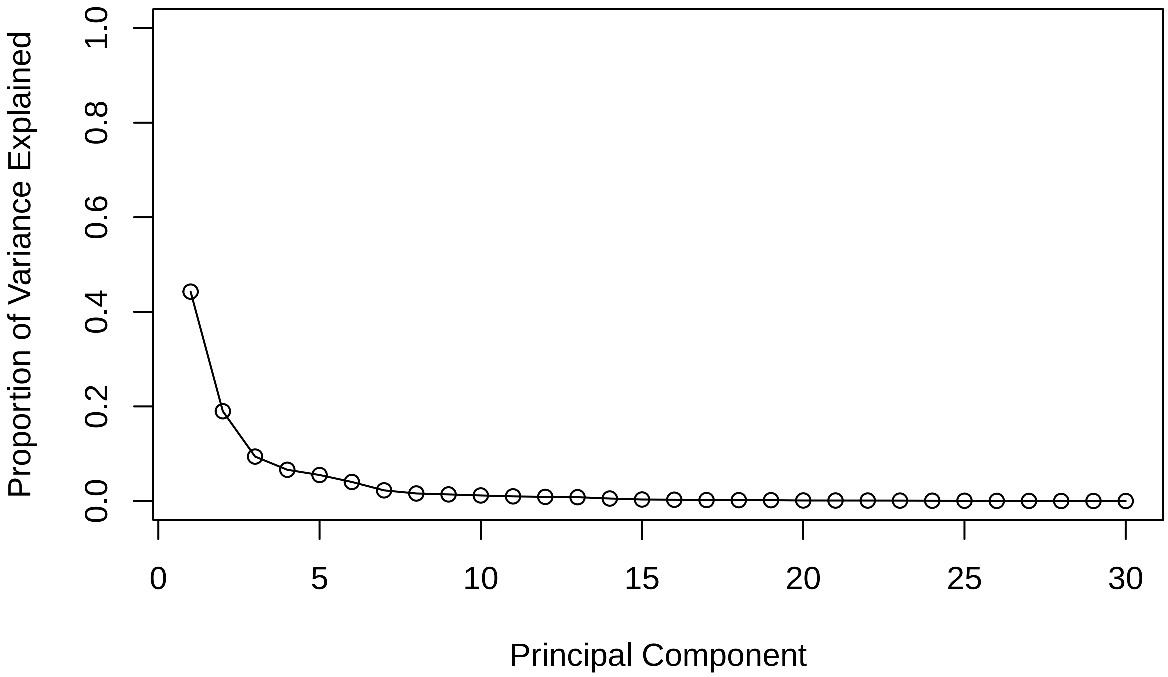
Variance explained

```
# Calculate variance of each component
#head(wisc.pr)
pr.var <- (wisc.pr$sdev)^2
head(pr.var)
```

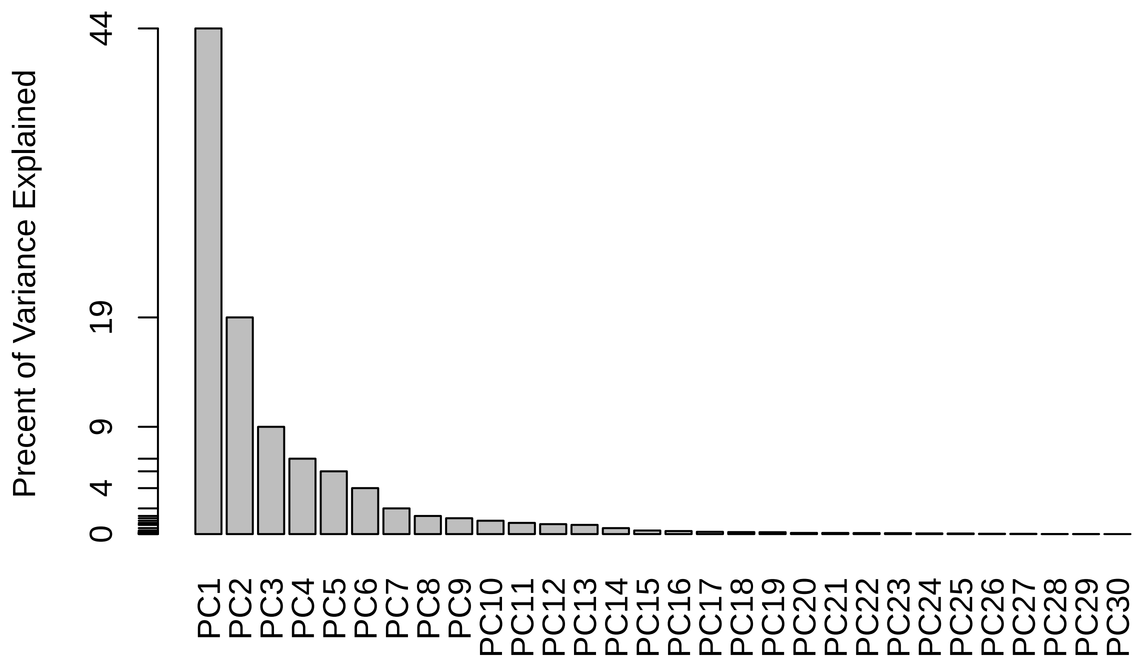
```
## [1] 13.281608  5.691355  2.817949  1.980640  1.648731  1.207357
```

```
# Variance explained by each principal component: pve
pve <- pr.var / sum(pr.var)

# Plot variance explained for each principal component
plot(pve, xlab = "Principal Component",
     ylab = "Proportion of Variance Explained",
     ylim = c(0, 1), type = "o")
```



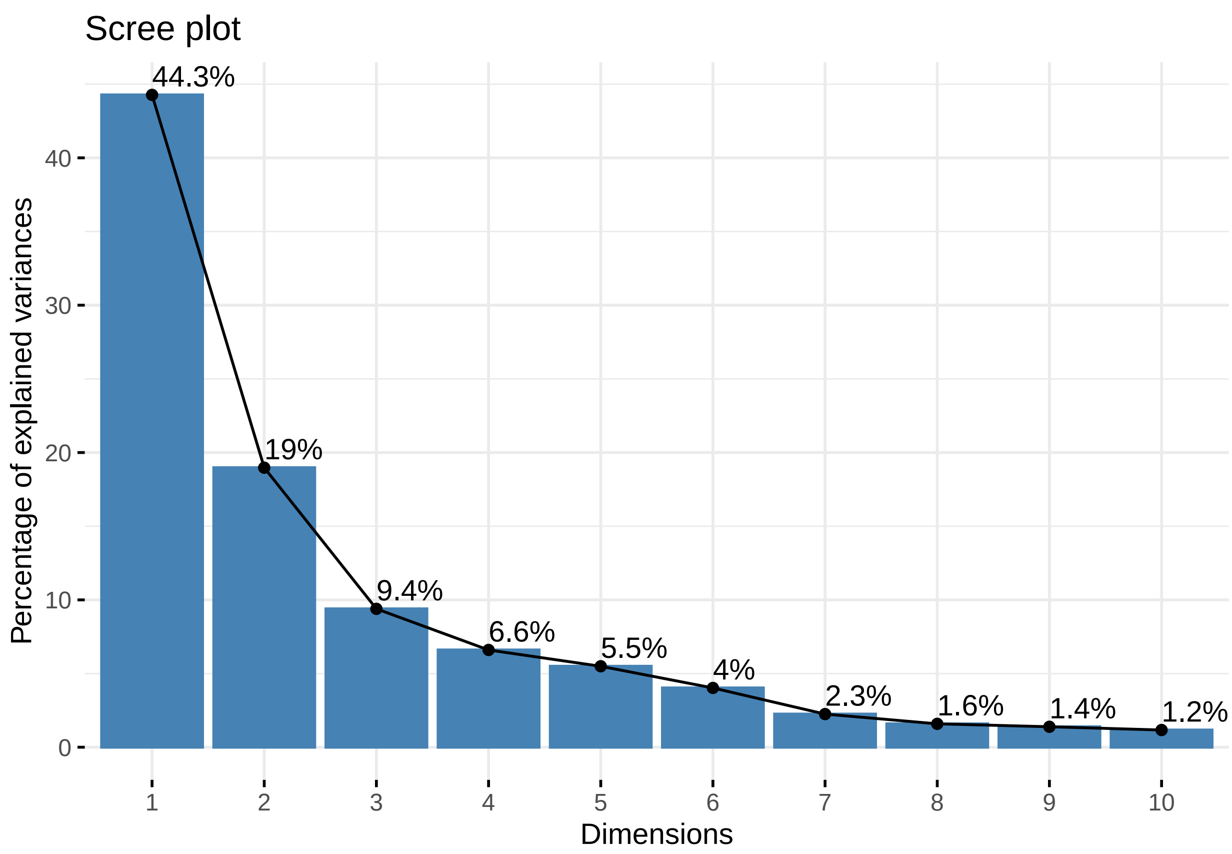

```
# Alternative scree plot of the same data, note data driven y-axis
barplot(pve, ylab = "Precent of Variance Explained",
     names.arg=paste0("PC",1:length(pve)), las=2, axes = FALSE)
axis(2, at=pve, labels=round(pve,2)*100 )
```




```
## ggplot based graph
#install.packages("factoextra")
library(factoextra)
```

```
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```

```
fviz_eig(wisc.pr, addlabels = TRUE)
```



Q9. For the first principal component, what is the component of the loading vector (i.e. wisc.pr$rotation[,1]) for the feature concave.points_mean?

```
wisc.pr$rotation["concave.points_mean",1]
```

```
## [1] -0.2608538
```

Q10. What is the minimum number of principal components required to explain 80% of the variance of the data?

-5 principles

```
wisc.pr$center
```

```
##             radius_mean            texture_mean          perimeter_mean
##            1.412729e+01            1.928965e+01            9.196903e+01
##               area_mean         smoothness_mean        compactness_mean
##            6.548891e+02            9.636028e-02            1.043410e-01
##          concavity_mean     concave.points_mean           symmetry_mean
##            8.879932e-02            4.891915e-02            1.811619e-01
##  fractal_dimension_mean               radius_se              texture_se
##            6.279761e-02            4.051721e-01            1.216853e+00
##            perimeter_se                 area_se           smoothness_se
```

```
##          2.866059e+00          4.033708e+01          7.040979e-03
##        compactness_se          concavity_se     concave.points_se
##          2.547814e-02          3.189372e-02          1.179614e-02
##           symmetry_se  fractal_dimension_se          radius_worst
##          2.054230e-02          3.794904e-03          1.626919e+01
##         texture_worst       perimeter_worst            area_worst
##          2.567722e+01          1.072612e+02          8.805831e+02
##      smoothness_worst     compactness_worst       concavity_worst
##          1.323686e-01          2.542650e-01          2.721885e-01
##  concave.points_worst        symmetry_worst fractal_dimension_worst
##          1.146062e-01          2.900756e-01          8.394582e-02
```

##Hierarchical clustering

```r
# Scale the wisc.data data using the "scale()" function
data.scaled <-scale(wisc.data)
```

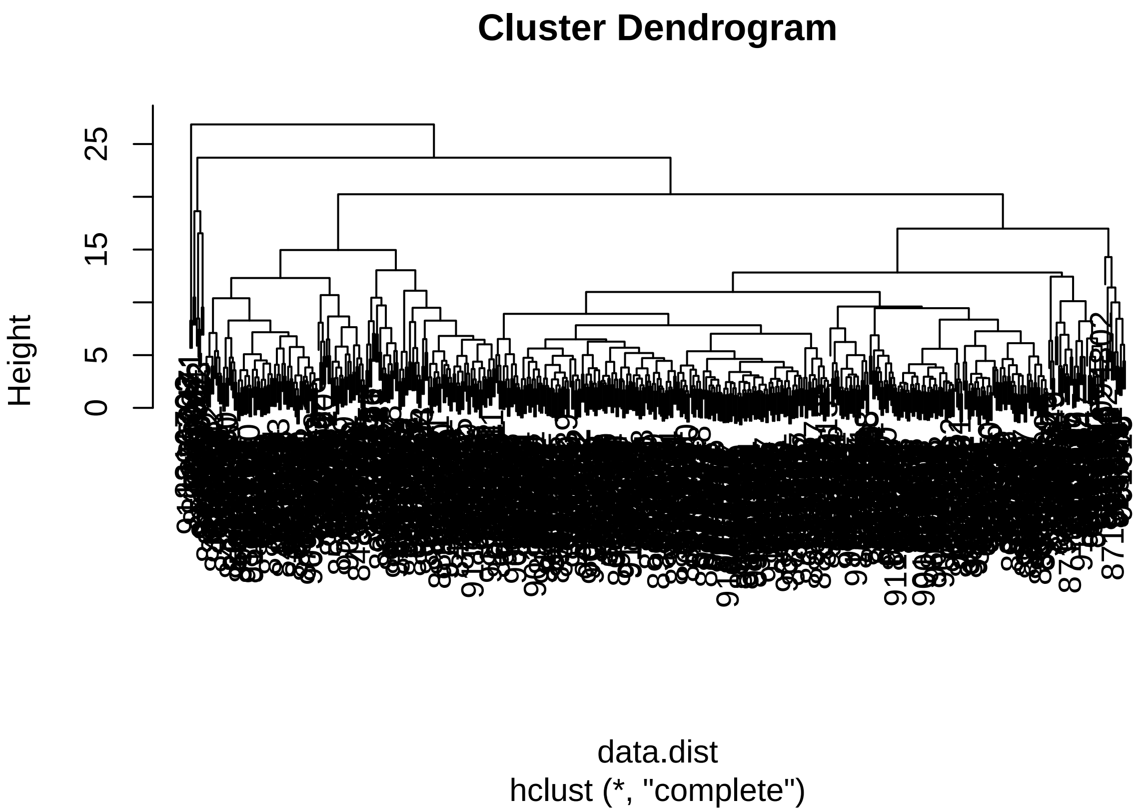
```r
data.dist <- dist(data.scaled)
```

```r
wisc.hclust <- hclust(data.dist, method="complete", members=NULL)
```

> Q11. Using the plot() and abline() functions, what is the height at which the clustering model has 4 clusters?

-height at 19

```r
plot(wisc.hclust)
abline(wisc.hclust, col="red", lty=2)
```




```
#library(rgl)
#plot3d(wisc.pr$x[,1:3], xlab="PC 1", ylab="PC 2", zlab="PC 3", cex=1.5, size=1, type="s", col=grps)
```

Selecting number of clusters

```
#Use cutree() to cut the tree so that it has 4 clusters. Assign the output to the variable wisc.hclust.
wisc.hclust.clusters <- cutree(wisc.hclust, k=4)
```

```
#We can use the table() function to compare the cluster membership to the actual diagnoses.
table(wisc.hclust.clusters, diagnosis)
```

```
##                     diagnosis
## wisc.hclust.clusters   B   M
##                    1  12 165
##                    2   2   5
##                    3 343  40
##                    4   0   2
```

Q12. Can you find a better cluster vs diagnoses match by cutting into a different number of clusters between 2 and 10?

```r
#cluster 2
wisc.hclust.clusters1 <- cutree(wisc.hclust, k=2)
table(wisc.hclust.clusters1, diagnosis)
```

```
##                       diagnosis
## wisc.hclust.clusters1   B   M
##                     1 357 210
##                     2   0   2
```

```r
#cluster 10
wisc.hclust.clusters2 <- cutree(wisc.hclust, k=10)
table(wisc.hclust.clusters2, diagnosis)
```

```
##                       diagnosis
## wisc.hclust.clusters2   B   M
##                    1   12  86
##                    2    0  59
##                    3    0   3
##                    4  331  39
##                    5    0  20
##                    6    2   0
##                    7   12   0
##                    8    0   2
##                    9    0   2
##                    10   0   1
```

```r
(357+164)/nrow(wisc.data)
```

```
## [1] 0.9156415
```

```r
(201+6)/nrow(wisc.data)
```

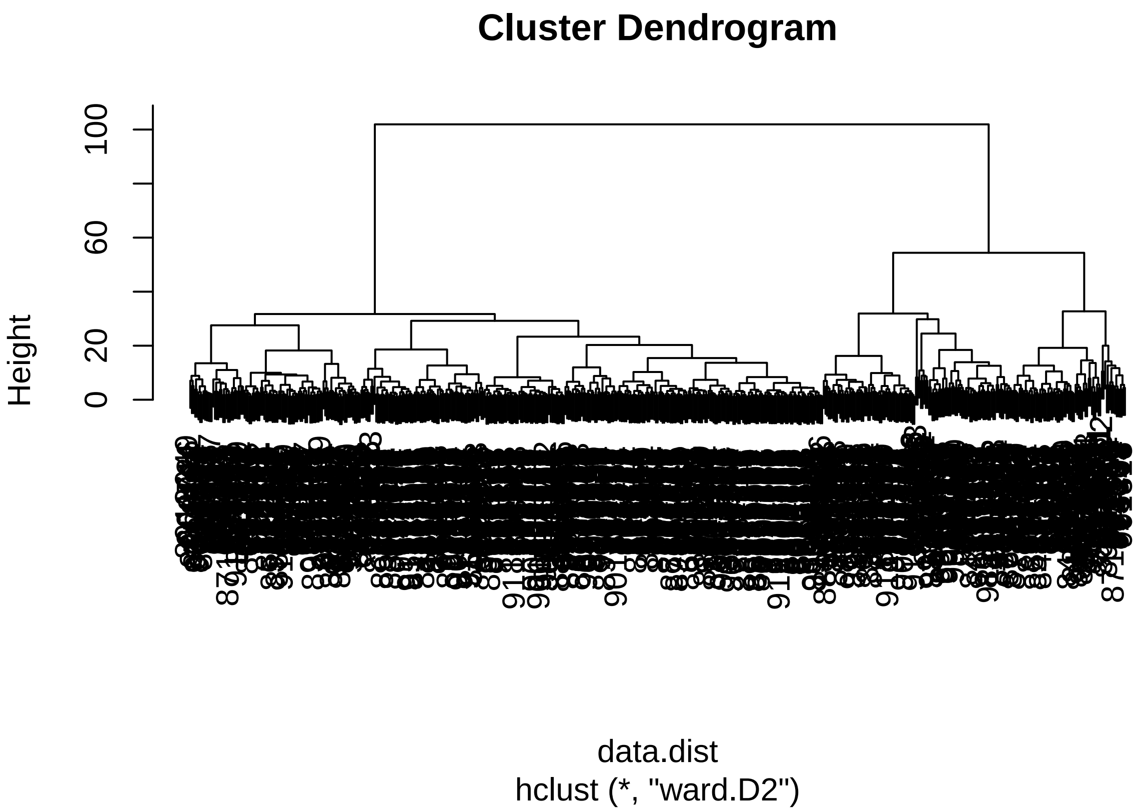
```
## [1] 0.3637961
```

Using different methods

> Q13. Which method gives your favorite results for the same data.dist dataset? Explain your reasoning.

- I like ward.D2 because it creates groups such that variance is minimized within clusters. It doesn't require squaring the Euclidean distances `dist()` are squared before inputing them to the `hclust()`

```r
wisc.hclustx <- hclust(data.dist, method="ward.D2", members=NULL)
plot(wisc.hclustx)
```



Combining methods

We take the results of our pca analysis and cluster in this space wisc.pr$x

```
summary(wisc.pr)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     3.6444 2.3857 1.67867 1.40735 1.28403 1.09880 0.82172
## Proportion of Variance 0.4427 0.1897 0.09393 0.06602 0.05496 0.04025 0.02251
## Cumulative Proportion  0.4427 0.6324 0.72636 0.79239 0.84734 0.88759 0.91010
##                            PC8    PC9    PC10   PC11    PC12    PC13    PC14
## Standard deviation     0.69037 0.6457 0.59219 0.5421 0.51104 0.49128 0.39624
## Proportion of Variance 0.01589 0.0139 0.01169 0.0098 0.00871 0.00805 0.00523
## Cumulative Proportion  0.92598 0.9399 0.95157 0.9614 0.97007 0.97812 0.98335
##                           PC15    PC16    PC17    PC18    PC19    PC20   PC21
## Standard deviation     0.30681 0.28260 0.24372 0.22939 0.22244 0.17652 0.1731
## Proportion of Variance 0.00314 0.00266 0.00198 0.00175 0.00165 0.00104 0.0010
## Cumulative Proportion  0.98649 0.98915 0.99113 0.99288 0.99453 0.99557 0.9966
##                           PC22    PC23   PC24    PC25    PC26    PC27    PC28
## Standard deviation     0.16565 0.15602 0.1344 0.12442 0.09043 0.08307 0.03987
## Proportion of Variance 0.00091 0.00081 0.0006 0.00052 0.00027 0.00023 0.00005
## Cumulative Proportion  0.99749 0.99830 0.9989 0.99942 0.99969 0.99992 0.99997
##                           PC29    PC30
```

```
## Standard deviation     0.02736 0.01153
## Proportion of Variance 0.00002 0.00000
## Cumulative Proportion  1.00000 1.00000
```

```r
wisc.pr$x[5,3]
```

```
## [1] 1.388545
```

```r
hclust(dist(wisc.pr$x[,1:3]))
```

```
##
## Call:
## hclust(d = dist(wisc.pr$x[, 1:3]))
##
## Cluster method   : complete
## Distance         : euclidean
## Number of objects: 569
```

```r
#Use the distance along the first 7 PCs for clustering
wisc.pr.hclust <- hclust(data.dist, method="ward.D2", members=NULL)
```

```r
wisc.pr.hclust.clusters <- cutree(wisc.pr.hclust, k=2)
```

crops table compare of diagnosis and my cluster groups

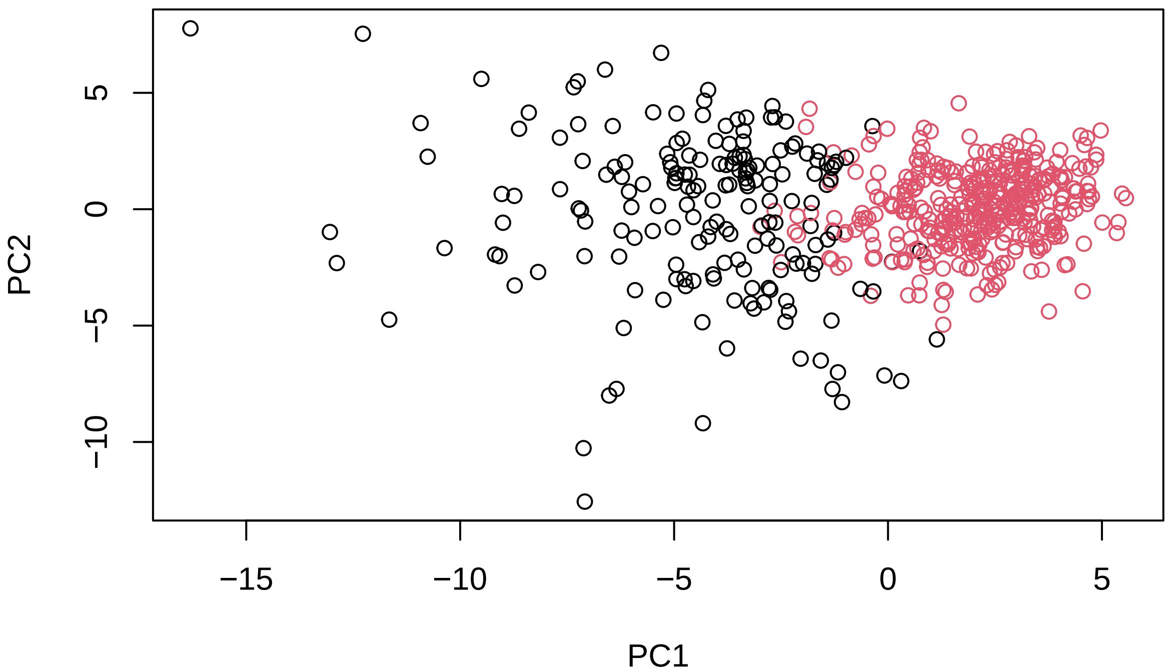
```r
grps <- cutree(wisc.pr.hclust, k=2)
table(grps)
```

```
## grps
##   1   2
## 184 385
```

```r
table (diagnosis, grps)
```

```
##          grps
## diagnosis   1   2
##         B  20 337
##         M 164  48
```

```r
plot(wisc.pr$x[,1:2], col=grps)
```



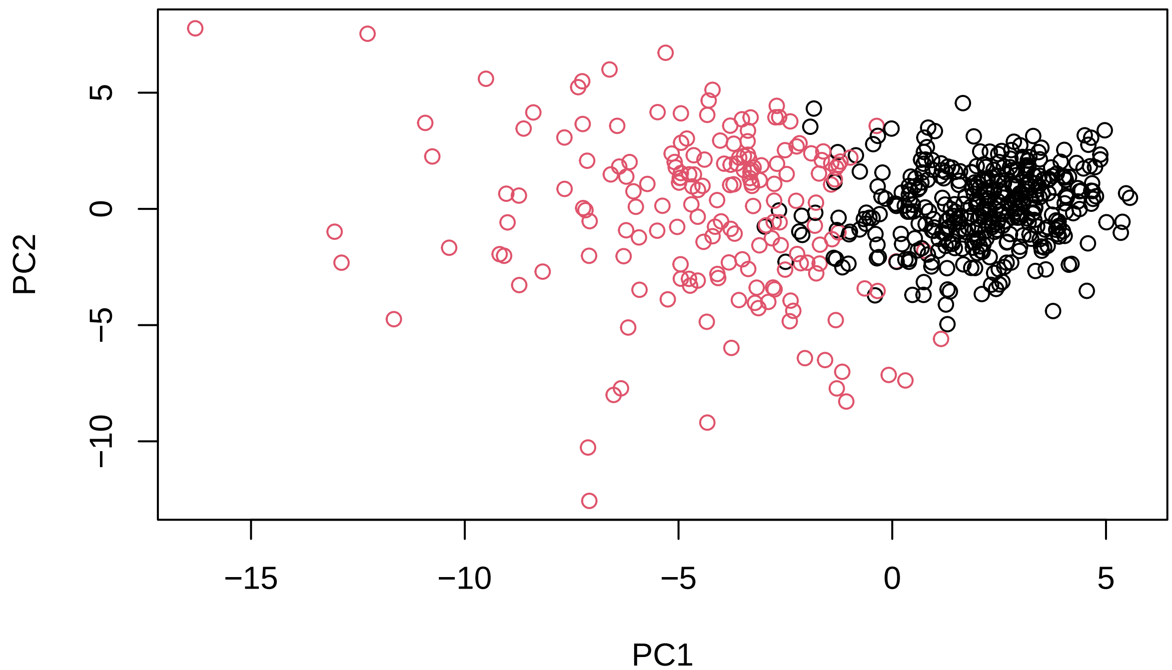

```r
g <- as.factor(grps)
levels(g)
```

```
## [1] "1" "2"
```

```r
g <- relevel(g,2)
levels(g)
```

```
## [1] "2" "1"
```

```r
# Plot using our re-ordered factor
plot(wisc.pr$x[,1:2], col=g)
```




```
#install.packages("rgl")
library(rgl)
plot3d(wisc.pr$x[,1:3], xlab="PC 1", ylab="PC 2", zlab="PC 3", cex=1.5, size=1, type="s", col=grps)
```

Sensitivity/ Specificity

```
#Use the distance along the first 7 PCs for clustering
wisc.pr.hclust <- hclust(data.dist, method="ward.D2", members=NULL)
```

```
wisc.pr.hclust.clusters <- cutree(wisc.pr.hclust, k=2)
```

Q15. How well does the newly created model with four clusters separate out the two diagnoses?

-the new model has 90.86% accuracy

```
# Compare to actual diagnoses
table(wisc.pr.hclust.clusters, diagnosis)
```

```
##                          diagnosis
## wisc.pr.hclust.clusters   B   M
##                         1  20 164
##                         2 337  48
```

> Q16. How well do the k-means and hierarchical clustering models you created in previous sections (i.e. before PCA) do in terms of separating the diagnoses? Again, use the table() function to compare the output of each model (wisc.km$cluster and wisc.hclust.clusters) with the vector containing the actual diagnoses.

-using wisc.km$cluster K-means clustering works the best in seperating diagnosis

```
table(wisc.hclust.clusters, diagnosis)
```

```
##                     diagnosis
## wisc.hclust.clusters   B   M
##                    1  12 165
##                    2   2   5
##                    3 343  40
##                    4   0   2
```

Accuracy what proportion did we get correct if we call cluster 1 M and cluster 2B

```
(329+188)/nrow(wisc.data)
```

```
## [1] 0.9086116
```

```
(175+343)/nrow(wisc.data)
```

```
## [1] 0.9103691
```

```
(165+343)/nrow(wisc.data)
```

```
## [1] 0.8927944
```

Sensitivity

```
(188)/(188+28)
```

```
## [1] 0.8703704
```

```
(175)/(175+14)
```

```
## [1] 0.9259259
```

```
(165)/(165+12)
```

```
## [1] 0.9322034
```

Specificity

```
329/(329+24)
```

```
## [1] 0.9320113
```

```
343/(343+37)
```

```
## [1] 0.9026316
```

```
343/(343+40)
```

```
## [1] 0.8955614
```

> Q17. Which of your analysis procedures resulted in a clustering model with the best specificity? How about sensitivity?

-specifcity: wisc.pr.hclust.clusters -sensitivity: wisc.hclust.clusters

Prediction

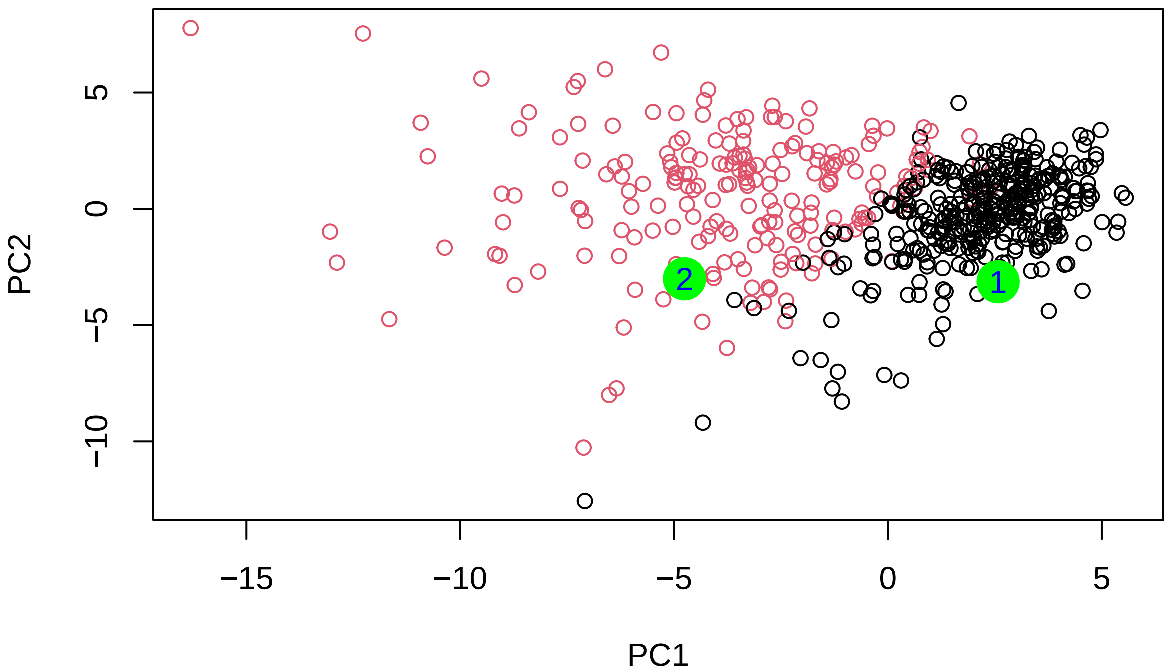
Here we read some new data and use PCA model to examine whether they most closely resemble M or B patients from our origional dataset

```
#url <- "new_samples.csv"
url <- "https://tinyurl.com/new-samples-CSV"
new <- read.csv(url)
npc <- predict(wisc.pr, newdata=new)
npc
```

```
##            PC1       PC2        PC3        PC4       PC5        PC6        PC7
## [1,]  2.576616 -3.135913  1.3990492 -0.7631950  2.781648 -0.8150185 -0.3959098
## [2,] -4.754928 -3.009033 -0.1660946 -0.6052952 -1.140698 -1.2189945  0.8193031
##             PC8       PC9       PC10      PC11      PC12      PC13     PC14
## [1,] -0.2307350 0.1029569 -0.9272861 0.3411457  0.375921 0.1610764 1.187882
## [2,] -0.3307423 0.5281896 -0.4855301 0.7173233 -1.185917 0.5893856 0.303029
##           PC15       PC16        PC17        PC18        PC19       PC20
## [1,] 0.3216974 -0.1743616 -0.07875393 -0.11207028 -0.08802955 -0.2495216
## [2,] 0.1299153  0.1448061 -0.40509706  0.06565549  0.25591230 -0.4289500
##            PC21       PC22       PC23       PC24        PC25         PC26
## [1,]  0.1228233 0.09358453 0.08347651  0.1223396  0.02124121  0.078884581
## [2,] -0.1224776 0.01732146 0.06316631 -0.2338618 -0.20755948 -0.009833238
##              PC27        PC28         PC29         PC30
## [1,]  0.220199544 -0.02946023 -0.015620933  0.005269029
## [2,] -0.001134152  0.09638361  0.002795349 -0.019015820
```

Plot onto our PCA model

```
plot(wisc.pr$x[,1:2], col=as.factor(diagnosis))
points(npc[,1],npc[,2], col="green", pch=16, cex=3)
text(npc[,1],npc[,2], labels = c(1,2), col="blue")
```



Q18. Which of these new patients should we prioritize for follow up based on your results?

-patient 2 id more malignant