Class08_Mini_Project

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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)
```

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

```
diagnosis <- wisc.df[1]
```

Q1. How many observations are in this dataset?

```
nrow(wisc.df)
```

```
[1] 569
```

There are 569 observations.

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

```
table(wisc.df$diagnosis)
```

```
  B   M
357 212
```

```
diagnosis <- (wisc.df$diagnosis)
```

```
length(grep("M", diagnosis))
```

```
[1] 212
```

There are 212 malignant diagnoses.

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

```
length (grep("_mean", colnames(wisc.df)))
```

```
[1] 10
```

There are 10 variables/features that are suffixed with _mean.

Principle Component Analysis

```
# 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
```

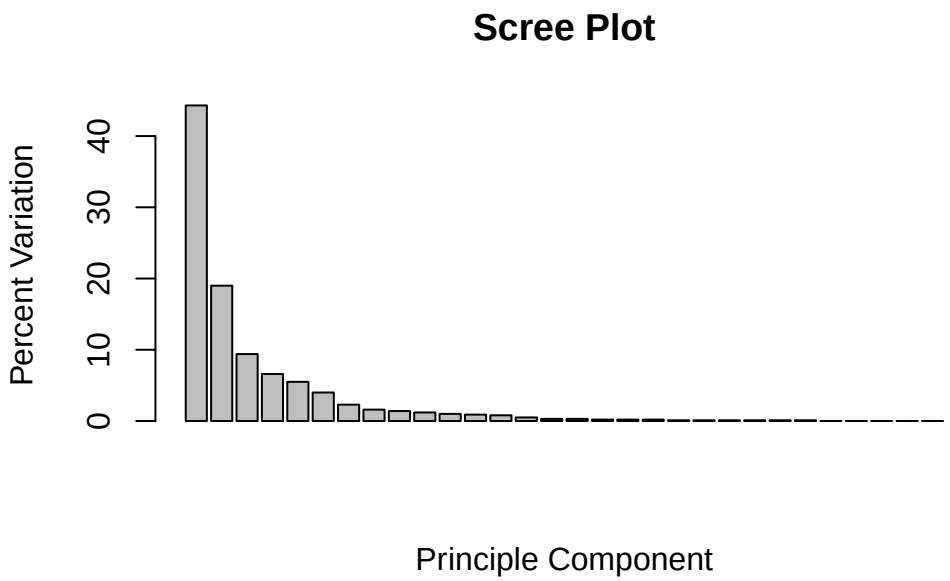
```
wisc.pr <- prcomp( wisc.data, scale = TRUE)
```

```
y <- summary(wisc.pr)
```

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

```
wisc.var <- y$sdev^2
wisc.var.per<- round(wisc.var/sum(wisc.var)*100,1)

barplot (wisc.var.per, main = "Scree Plot", xlab = "Principle Component", ylab= "Percent V
```



Around 40%

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

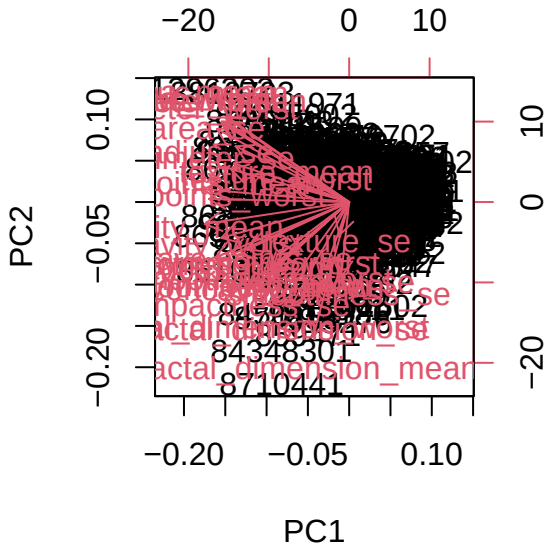
The first 3 PCAs.

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

The first 5 PCAs.

Interpreting PCA Results

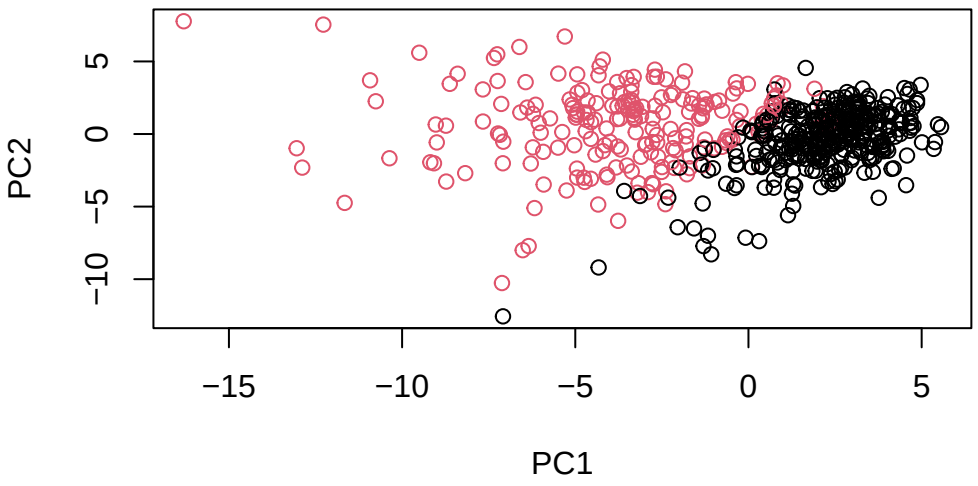
```
biplot(wisc.pr)
```



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

The plot has many overlapping labels. It is difficult to understand because the rownames are used as plotting character for bigplots like this.

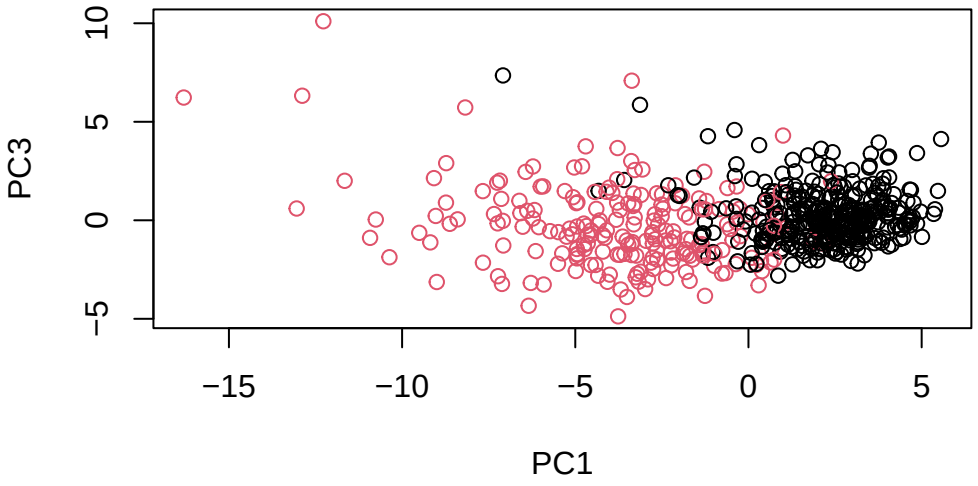
```
# Scatter plot observations by components 1 and 2
plot( wisc.pr$x[,1], wisc.pr$x[,2] , col = as.factor(diagnosis),
     xlab = "PC1", ylab = "PC2")
```



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

The y-axis is different and smaller for the graph of PCA1 and PCA2.

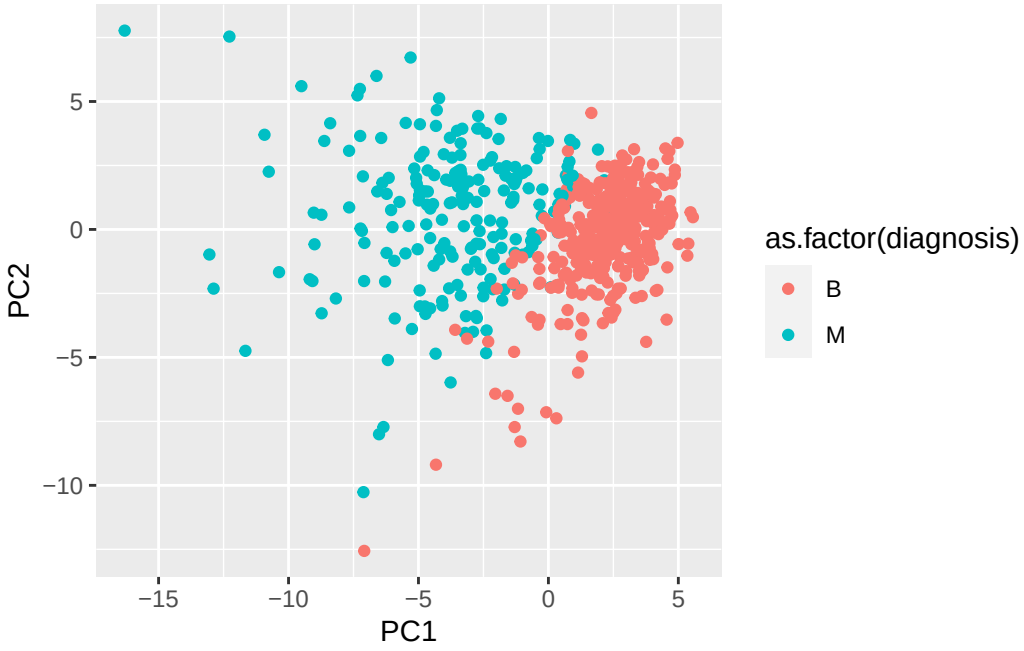
```
plot( wisc.pr$x[,1], wisc.pr$x[,3] , col = as.factor(diagnosis),
     xlab = "PC1", ylab = "PC3")
```




```
# 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, col= as.factor(diagnosis)) +
  geom_point()
```

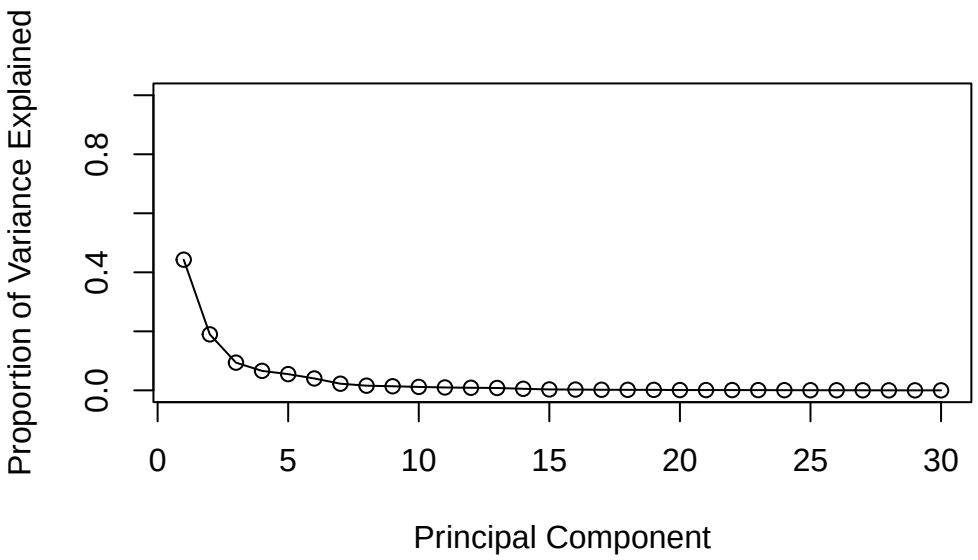



```
# Calculate variance of each component
pr.var <- wisc.pr$sdev^2
head(pr.var)
```

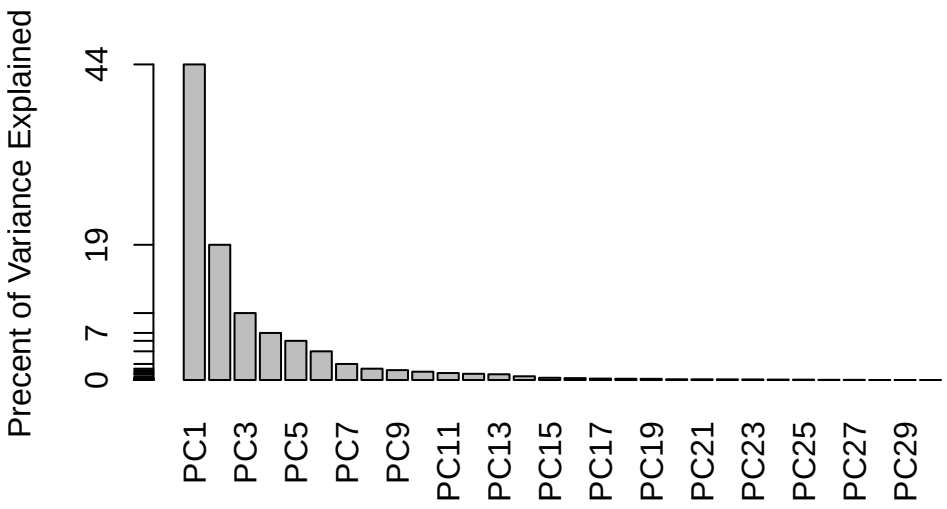
```
[1] 13.281608  5.691355  2.817949  1.980640  1.648731  1.207357
```

```
# 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")
```



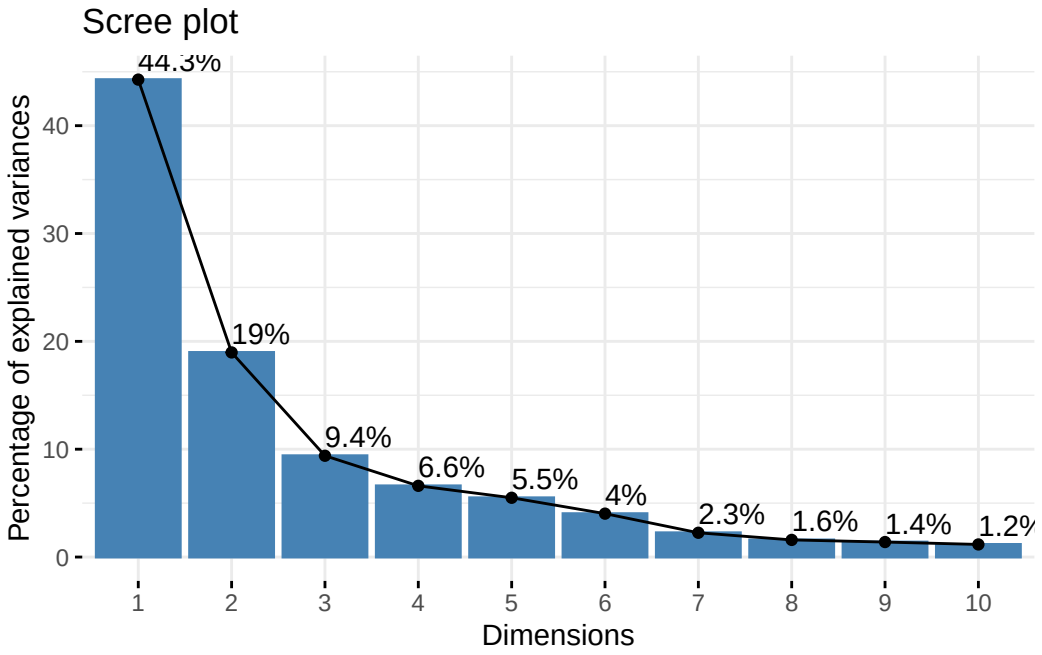

```
# Alternative scree plot of the same data, note data driven y-axis
barplot(pve, ylab = "Precent of Variance Explained",
     names.arg=paste0("PC",1:length(pve)), las=2, axes = FALSE)
axis(2, at=pve, labels=round(pve,2)*100 )
```




```
## 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)
```



Communicating PCA Results

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`? This tells us how much this original feature contributes to the first PC.

For PCA 1 it is, -0.14258969

```
wisc.pr$rotation
```

	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
```

Hierarchical Clustering

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

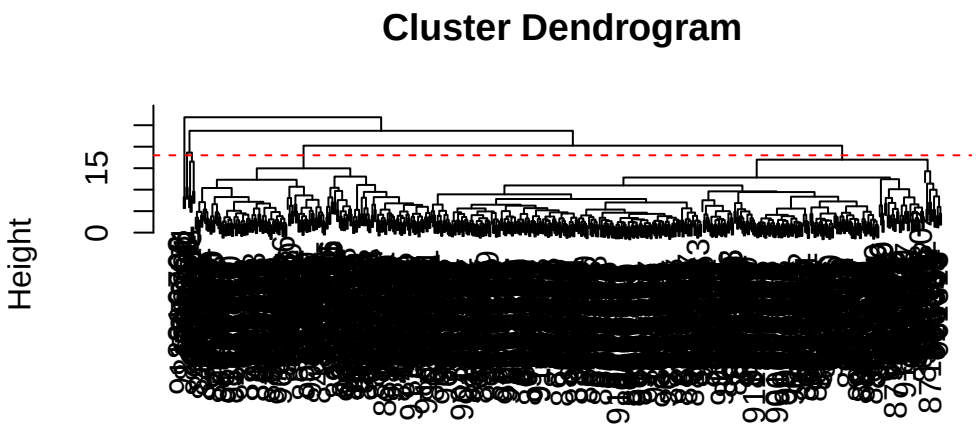
```r
data.dist <- dist(data.scaled)
```

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

Q10. Using the `plot()` and `abline()` functions, what is the height at which the clustering model has 4 clusters?

Between 15 and 20

```r
plot(wisc.hclust)
abline(h = 18 , col="red", lty=2)
```




```
wisc.hclust.clusters <- cutree(wisc.hclust, k = 4)
```

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

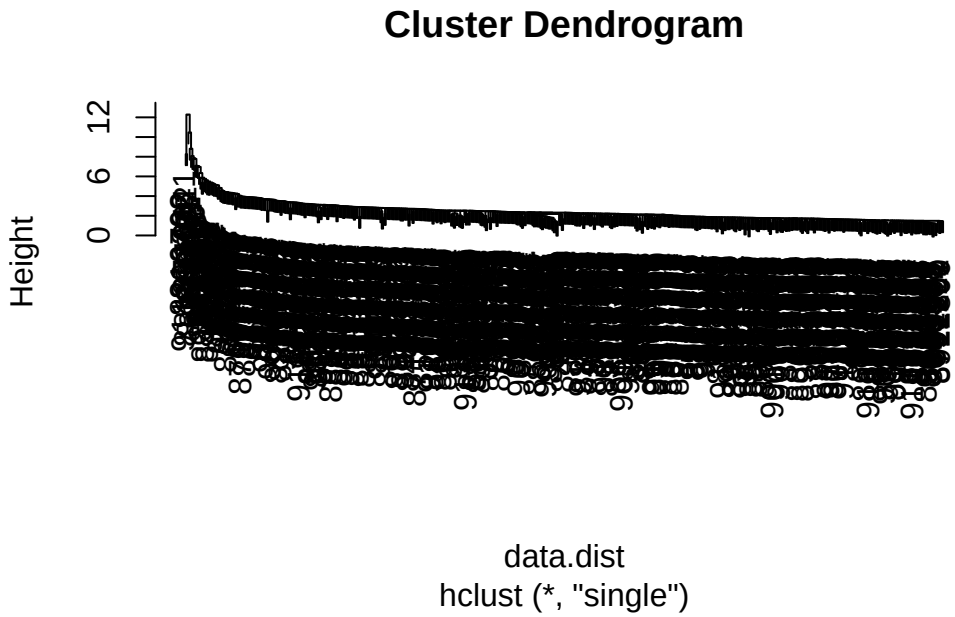
```
                    diagnosis
wisc.hclust.clusters   B   M
                   1  12 165
                   2   2   5
                   3 343  40
                   4   0   2
```

Using Different Methods

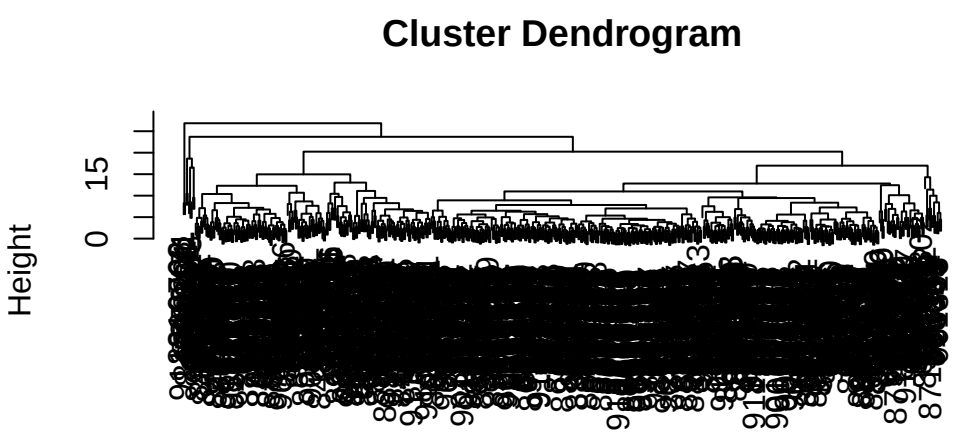
Q12. Which method gives your favorite results for the same `data.dist` dataset? Explain your reasoning.

I prefer complete because it is easier to see the branches in the tree in comparison to single, average, and ward2 which show less separations into different branches.

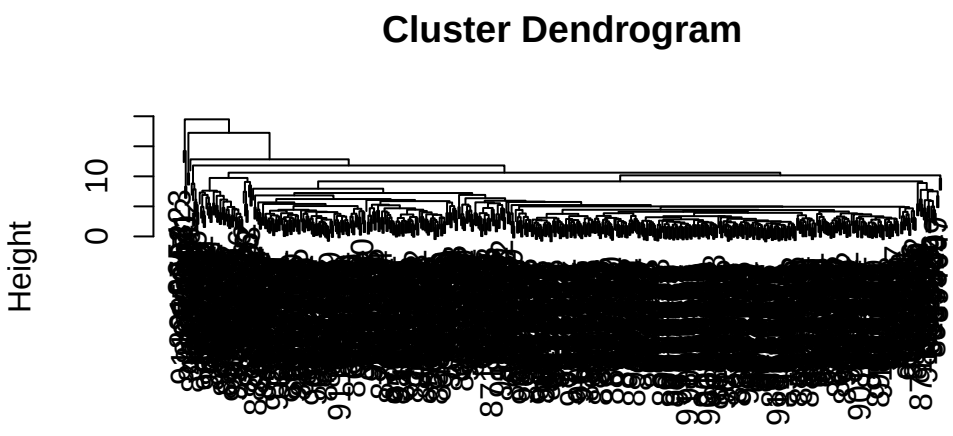
```
wisc.hclust.single <- hclust (data.dist, method = "single" )
wisc.hclust.complete <- hclust (data.dist, method = "complete" )
wisc.hclust.avg <- hclust (data.dist, method = "average" )
wisc.hclust.ward <- hclust (data.dist, method = "ward.D2" )
plot(wisc.hclust.single)
```



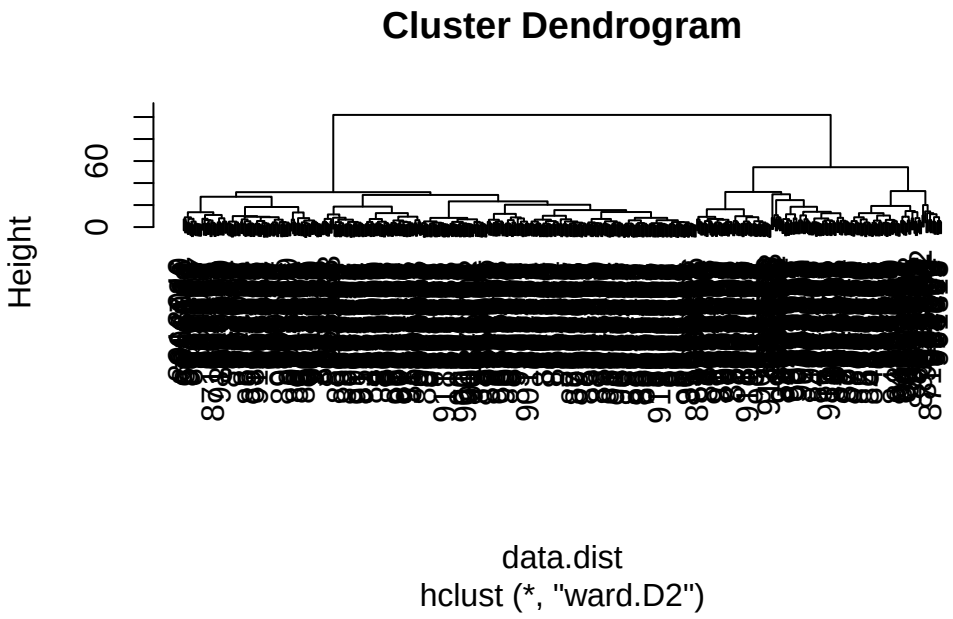

```
plot(wisc.hclust.complete)
```




```
plot(wisc.hclust.avg)
```



```
plot(wisc.hclust.ward)
```



Combining Methods

Clustering on PCA Results

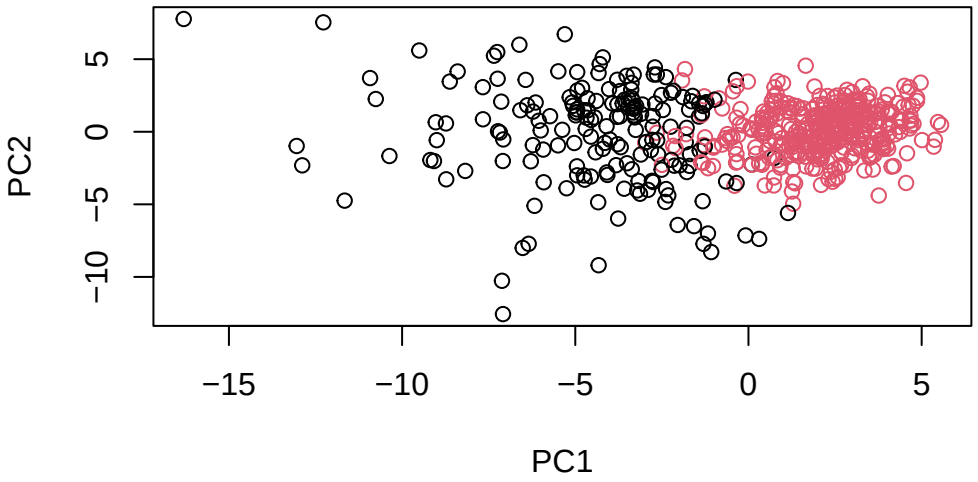
```
grps <- cutree(wisc.hclust.ward , k=2)
table(grps)
```

```
grps
  1   2
184 385
```

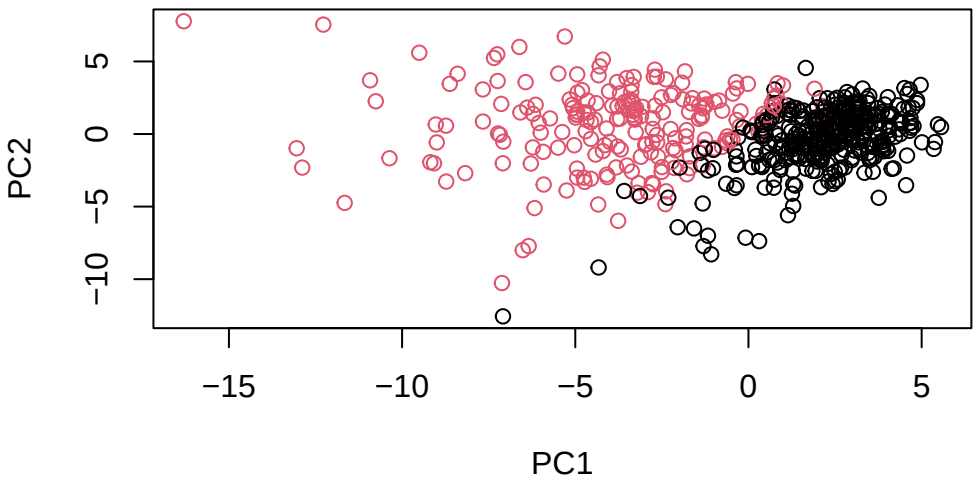
```
table(grps, diagnosis)
```

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

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




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



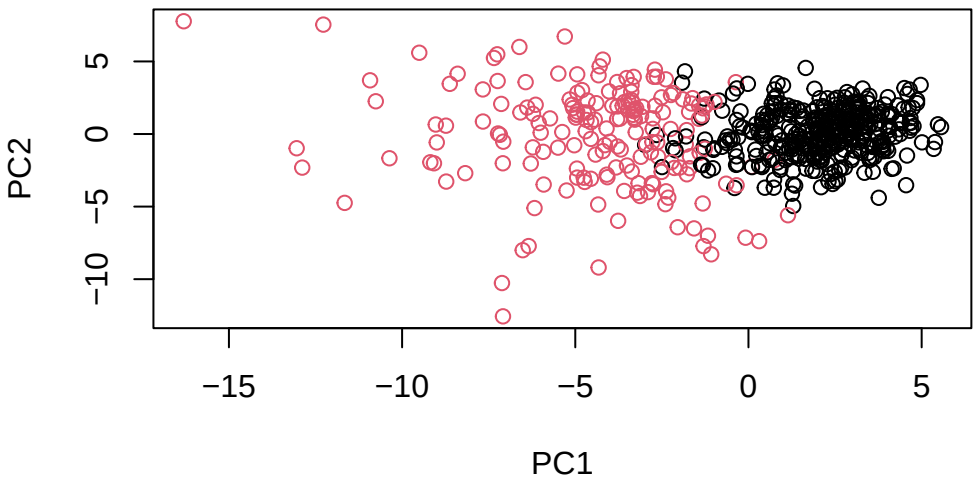

```
g <- as.factor(grps)
levels(g)
```

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

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

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

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



Q13. How well does the newly created model with four clusters separate out the two diagnoses?

Not very well since there are large gaps in the diagnoses in comparison to the actual.

```
## Use the distance along the first 7 PCs for clustering i.e. wisc.pr$x[, 1:7]
wisc.pr.hclust <- hclust(dist(wisc.pr$x[, 1:7]), method="ward.D2")
wisc.pr.hclust.clusters <- cutree(wisc.pr.hclust, k=2)
table(wisc.pr.hclust.clusters, diagnosis)
```

```
                    diagnosis
wisc.pr.hclust.clusters   B   M
                      1  28 188
                      2 329  24
```

Q14. How well do the 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.

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

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

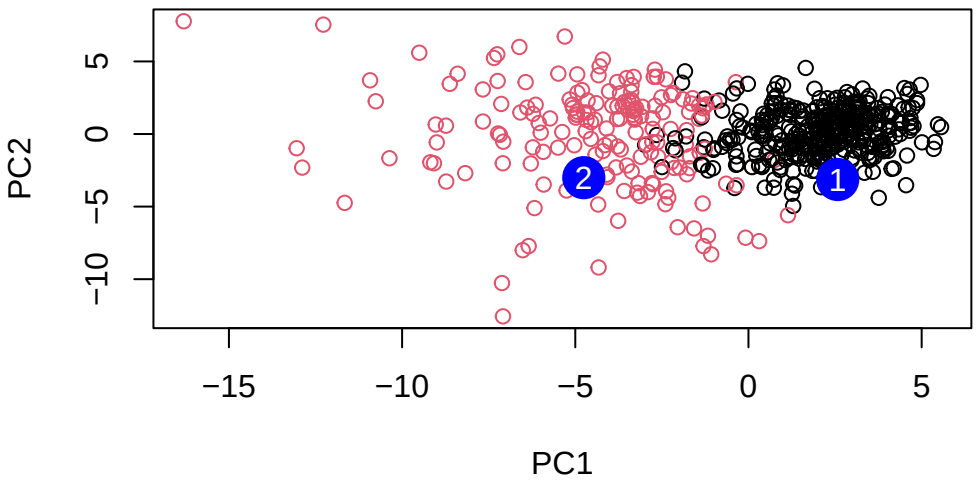
Q16. Which of these new patients should we prioritize for follow up based on your results?

We should prioritize patient 2 since they are within the malignant or red cluster.

```
#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(wisc.pr$x[,1:2], col=g)
points(npc[,1], npc[,2], col="blue", pch=16, cex=3)
text(npc[,1], npc[,2], c(1,2), col="white")
```


PC2
5
0
−5
−10
−15
−10
−5
0
5
PC1
2
1