Canonical correlation

KEY

Wed May 6 16:00:15 2020

Canonical correlation

We will work with data on blood analysis from sea turtles in Florida. Import the data into a data frame called blood:

```
library(readxl)

data.frame(read_excel("sea_turtle_blood_chemistry.xlsx")) -> blood
```

Make lists of ions and large molecules that will be used to make the matrices for our canonical correlation analysis:

```
ions <- c("log.ca", "log.p",  "log.mg", "log.na", "log.k",  "cl" )

big.molecules <- c("glucose",  "urea.nitrogen", "log.uric.acid",
"cholesterol", "log.total.protein", "log.albumin")
```

Calculate the correlations between ions and big molecules:

```
cor(blood[big.molecules],blood[ions])
```

```
##                       log.ca      log.p      log.mg     log.na      log.k
## glucose            0.1558721 0.40388104 -0.04060951  0.2326246  0.1450242
## urea.nitrogen     -0.5586249 0.01534155 -0.23243973 -0.4390901 -0.4930474
## log.uric.acid      0.2870265 0.06614801  0.27701871  0.1652534  0.4038348
## cholesterol        0.2517264 0.25088187  0.21944649  0.1920317  0.1793705
## log.total.protein  0.5766598 0.11728741  0.14224429  0.3035283  0.4027942
## log.albumin        0.3253949 0.09284918  0.19517943  0.3971650  0.3778493
##                           cl
## glucose            0.280103678
## urea.nitrogen      0.190662489
## log.uric.acid     -0.173216770
## cholesterol       -0.070305690
## log.total.protein  0.003973512
## log.albumin        0.080395533
```

Question: what are the two strongest correlations between the two sets of variables (give the correlation coefficients and the pairs of variables)?

The strongest correlations are not very big - there is a correlation of 0.57 between log.total.protein and log.ca, and one of -0.558 between urea.nitrogen and log.ca.

Conduct the CC

Load the library:

```
library(CCA)
```

```
## Loading required package: fda
```

```
## Loading required package: splines
```

```
## Loading required package: Matrix
```

```
##
## Attaching package: 'fda'
```

```
## The following object is masked from 'package:graphics':
##
##     matplot
```

```
## Loading required package: fields
```

```
## Loading required package: spam
```

```
## Loading required package: dotCall64
```

```
## Loading required package: grid
```

```
## Spam version 2.5-1 (2019-12-12) is loaded.
## Type 'help( Spam)' or 'demo( spam)' for a short introduction
## and overview of this package.
## Help for individual functions is also obtained by adding the
## suffix '.spam' to the function name, e.g. 'help( chol.spam)'.
```

```
##
## Attaching package: 'spam'
```

```
## The following object is masked from 'package:Matrix':
##
##     det
```

```
## The following objects are masked from 'package:base':
##
##     backsolve, forwardsolve
```

```
## Loading required package: maps
```

```
## See https://github.com/NCAR/Fields for
##  an extensive vignette, other supplements and source code
```

Run the canonical correlation analysis:

```
cc(blood[ions], blood[big.molecules]) -> blood.cc

blood.cc
```

```
## $cor
## [1] 0.7934713 0.5221962 0.4584981 0.2994990 0.2118688 0.1022423
##
## $names
## $names$Xnames
## [1] "log.ca" "log.p"  "log.mg" "log.na" "log.k"  "cl"
##
## $names$Ynames
## [1] "glucose"           "urea.nitrogen"     "log.uric.acid"
## [4] "cholesterol"       "log.total.protein" "log.albumin"
##
## $names$ind.names
##  [1] "1"  "2"  "3"  "4"  "5"  "6"  "7"  "8"  "9"  "10" "11" "12" "13" "14"
## [15] "15" "16" "17" "18" "19" "20" "21" "22" "23" "24" "25" "26" "27" "28"
## [29] "29" "30" "31" "32" "33" "34" "35" "36" "37" "38" "39" "40" "41" "42"
## [43] "43" "44" "45" "46" "47" "48" "49" "50" "51" "52" "53" "54" "55" "56"
## [57] "57" "58" "59" "60" "61" "62" "63" "64" "65" "66" "67" "68" "69" "70"
## [71] "71" "72" "73" "74" "75" "76" "77"
##
##
## $xcoef
##               [,1]        [,2]          [,3]         [,4]       [,5]
## log.ca -3.38080749  0.07664462   6.886963769   2.15319997 -0.6029992
## log.p  -3.20640040 -4.61221203  -0.217097795   5.31044526  1.5627525
## log.mg  0.41712268  1.86364590  -1.605980221   2.45060209 -1.1025838
## log.na -9.25338868 -6.16107223 -16.694024056 -19.83203235 24.3999929
## log.k  -2.21121689  0.93960230  -5.749991505  -2.56342822 -4.5768166
## cl      0.02196259 -0.09090062  -0.009263842  -0.02133627 -0.1073680
##               [,6]
## log.ca  1.83094221
## log.p  -1.84534673
## log.mg  2.78116813
## log.na  2.54884009
## log.k  -4.49286534
## cl      0.07466927
##
## $ycoef
##                          [,1]         [,2]         [,3]         [,4]
## glucose           -0.031074142 -0.088178590 -0.007448884 -0.001323528
## urea.nitrogen      0.032437294 -0.006526056 -0.012935039  0.022582887
## log.uric.acid     -0.457119621  1.124471037 -1.917930507  1.304554522
## cholesterol       -0.001883991  0.006280926 -0.008236814  0.025546472
## log.total.protein -2.778193513  0.369432458  7.675982525 -0.112885032
## log.albumin        0.064531882  0.152511634 -3.525791723 -1.384671845
##                          [,5]        [,6]
## glucose            0.01224967 -0.04745496
## urea.nitrogen     -0.04581523  0.02446641
## log.uric.acid     -2.02939849 -1.42345213
## cholesterol        0.01836450  0.01305940
## log.total.protein -5.43401899  2.03467630
```

```
## log.albumin       -1.25732538  2.68443873
##
## $scores
## $scores$xscores
##              [,1]         [,2]        [,3]        [,4]         [,5]
##  [1,]  0.23599858 -2.485822194  0.67432868  1.59368517 -1.650030035
##  [2,] -0.25288934  0.040009057 -0.39043657  1.02463244  0.516680046
##  [3,]  0.24160748  0.292136475  0.52084782  1.43454410 -0.516908425
##  [4,]  0.36703425  0.492637302  1.00748969  0.47090157  0.129047781
##  [5,]  0.98475753  0.455864780  0.54486082  1.14504522 -0.280383871
##  [6,]  1.17325619  0.529083765 -0.01952218  0.20224838  1.007057856
##  [7,]  0.55057150 -0.131554803  0.44552541  0.90108074  0.139023760
##  [8,]  1.27243129 -0.124693639  0.03785979 -0.05766070 -0.015987265
##  [9,]  0.78662284  0.770112828  0.46850889  0.35510244  1.233203728
## [10,]  1.14035001 -0.493502386 -0.35744902 -0.14560822  0.164197918
## [11,] -0.51236699 -1.390870576 -0.72775865 -0.38412488  1.381602208
## [12,]  0.33284133 -0.591746353  0.47539632  0.77543973 -0.007423235
## [13,]  0.89972315 -0.077855243 -0.47415535 -0.65691630 -0.002390095
## [14,]  1.08620753 -0.436730327 -1.16036803 -1.47377931 -0.770559692
## [15,]  0.48771124 -0.192983282 -0.17749492 -0.17493235 -0.512275636
## [16,]  1.21283159  0.106114921 -1.12969587 -1.46431398 -0.531846707
## [17,]  2.43271645 -0.351676152 -1.07040903 -1.13739369 -0.675041883
## [18,]  1.33949891 -2.626361623 -1.85195169 -0.32918313  1.034427426
## [19,]  0.64746294 -1.637123354  0.24185787 -0.63857359  0.254321344
## [20,]  0.93723511 -0.194266985  0.35324511  0.56411345  0.919879489
## [21,]  0.57235191 -0.465950505  0.15532249 -0.14619260  0.871820526
## [22,]  0.85069186  0.172298838  0.43245669  0.93232406  0.203840286
## [23,]  0.29620223 -0.581157770  0.06462873  0.48048079  0.427083675
## [24,]  0.52612042 -0.597397733 -0.41137490  0.53635912 -0.091999489
## [25,]  0.22442865  0.069995681  1.11987266  1.01852665 -0.036128212
## [26,]  0.91709995  0.128708085  0.51061558  0.08426110 -0.385428989
## [27,]  1.22737186 -0.856510633 -0.13542638 -1.74332687 -1.817563222
## [28,] -0.34748331 -1.775824316  1.10747835 -0.51790969 -0.773998644
## [29,]  0.87478789 -0.795161573  1.83494735 -0.53314222 -0.564271898
## [30,]  0.03546464 -1.279119426  0.21327730  0.75588146 -0.086931535
## [31,]  0.77687488  0.295708458  0.60956278  0.69790030 -0.353417728
## [32,]  0.63452414 -0.007673456  0.19415314 -0.55480148  1.123536153
## [33,]  0.95610863  0.607801794  1.80921363  0.42383037  0.940374978
## [34,]  0.19946994  0.358737151  0.30606799 -0.17946119  0.389950750
## [35,]  0.49393029 -0.039887214  0.63108170 -0.87050720 -0.809005034
## [36,]  0.44572428 -0.143408155  0.29663077 -0.84743911 -1.203175427
## [37,] -0.61447218  1.637868040 -1.54880664 -1.33307063 -3.586640818
## [38,]  1.36548991  1.280655096  1.59127985 -0.77020314 -0.030039708
## [39,] -0.56851952 -0.839145265  0.04163137  0.16463367 -0.468017434
## [40,]  0.03638032 -0.538635993  0.72779137  1.08449651  0.273704375
## [41,]  0.07343534 -0.280708096  0.13647102  1.30241985  0.919164337
## [42,]  0.27990428  0.543945557  0.81636971 -0.05035799 -0.080412880
## [43,] -0.77389795 -2.388981973 -0.57563883  1.24309980  0.111370722
## [44,] -0.39990790 -1.261472168 -0.80316442  1.64883726  0.075003525
## [45,] -2.89323280 -0.361637054  0.41155480 -0.17251684  0.781237653
```

```
## [46,]  1.45997825  2.048147329 -0.39574053  0.49959363 -1.394552814
## [47,] -0.22263990  0.159686449 -2.57845577  2.36326748  0.803959528
## [48,]  0.17554112  1.580716819 -1.03470221  1.05126209  1.834938348
## [49,]  0.44242396  1.661948650 -1.66102828  0.40828981  1.633109282
## [50,]  0.47788495  2.072591925 -1.16839600  0.40373939  1.336970070
## [51,]  0.01078640  1.914753171 -1.29925831 -0.51332563  0.267443835
## [52,] -1.73780184  0.587856411 -0.93186693 -1.12879420  0.505740740
## [53,] -0.62501525  0.998577351  0.01448636 -0.05759167  0.193017778
## [54,] -0.90545041 -0.069897553 -0.53710076  1.29740602 -2.274445423
## [55,] -1.44161808  0.339570023  0.83337250 -1.56354376 -0.815856132
## [56,] -2.01908987 -0.076462857 -0.71149256  0.46697164 -0.794101406
## [57,] -1.35807454 -0.849617318 -1.39959884  0.07269295 -0.056521992
## [58,] -0.10884854 -1.485139334 -2.59769932 -0.37646107 -0.150496231
## [59,] -1.36358100 -0.852109836 -0.28852080 -2.54869515  0.042837592
## [60,]  0.39600770 -1.061365929 -0.10037006 -2.16074211  1.119608122
## [61,]  0.30244146  1.525830238 -0.99315457 -0.51674905  0.186845844
## [62,] -0.47762430  0.309387835  1.04258053 -1.23846951  0.930608612
## [63,]  0.17936092  1.107092001 -1.57091434  0.22431730 -0.525403168
## [64,] -1.19071185 -0.326527273  0.47713570 -1.41677997  0.046839707
## [65,] -0.13175309  1.169372395  1.24671622  2.00403621 -2.877898233
## [66,] -1.26408718 -0.316044537 -1.14410358  0.59962317  0.103562040
## [67,] -1.56933085  0.858926186  0.18550828  0.36912086 -0.375065873
## [68,] -0.75664960  0.040203121  0.66965325 -0.40972846 -1.607168204
## [69,] -1.39173554  0.028141687  2.10760548 -0.64283560  0.147117383
## [70,]  0.19640388 -0.429068819  0.74785858 -1.19769456  0.902858311
## [71,] -2.31027927 -0.262575388 -0.23728990  1.63042807 -0.105645345
## [72,] -1.03170094  1.830875624 -0.60035756 -0.51477277 -0.509024292
## [73,] -1.99875459  0.577784189  0.30421375 -1.53913150  2.212918489
## [74,] -0.90272051  0.668562034  1.41068737  0.09029530 -0.031711896
## [75,] -0.81081050  0.049494102  1.25029800  0.72781624  0.524126201
## [76,] -0.61180891  0.825982940 -0.15632030 -0.88727738 -0.570033016
## [77,]  0.03680855  0.539488777  2.16957943 -0.15469682  1.648771469
##              [,6]
##  [1,]  0.32779828
##  [2,] -1.10600171
##  [3,]  0.45762829
##  [4,] -0.75356482
##  [5,] -0.94310131
##  [6,] -1.20293269
##  [7,] -0.20416567
##  [8,]  0.59848744
##  [9,]  0.48849336
## [10,]  1.44618476
## [11,]  0.38820879
## [12,]  0.24292615
## [13,] -0.28285195
## [14,]  0.19552851
## [15,] -0.25087173
## [16,] -0.09364337
## [17,]  1.04980428
```

```
## [18,] -1.07014641
## [19,] -0.25231379
## [20,]  0.49817271
## [21,] -0.29006435
## [22,]  0.58371149
## [23,]  0.14503376
## [24,]  0.23699161
## [25,]  0.41328692
## [26,]  0.47207002
## [27,]  1.11234074
## [28,] -0.15720260
## [29,] -0.90305916
## [30,]  0.78730451
## [31,]  0.46533560
## [32,] -0.26854472
## [33,] -0.19365787
## [34,]  0.17439144
## [35,]  0.66602556
## [36,]  1.10045950
## [37,] -4.25701946
## [38,] -1.48910735
## [39,]  0.17290454
## [40,]  0.81008740
## [41,]  0.23684799
## [42,]  1.07015874
## [43,] -0.63328845
## [44,] -0.50006457
## [45,]  0.89911868
## [46,]  0.12438394
## [47,] -1.42372332
## [48,] -1.30208386
## [49,] -0.54076865
## [50,]  0.45047447
## [51,]  1.66376119
## [52,]  1.19952839
## [53,]  0.42317008
## [54,] -0.41649420
## [55,]  1.10935294
## [56,] -0.01779853
## [57,]  0.14228399
## [58,] -0.42372020
## [59,] -1.09494553
## [60,] -0.73540985
## [61,]  0.38173721
## [62,] -0.45274705
## [63,]  1.72764097
## [64,]  1.28168664
## [65,] -0.34962714
## [66,]  0.07486850
## [67,]  0.07887957
```

```
## [68,]  0.47275749
## [69,] -0.70801489
## [70,] -1.31330267
## [71,]  1.70538048
## [72,]  1.67453854
## [73,] -1.14537363
## [74,] -1.92144700
## [75,] -2.29464186
## [76,]  0.59933246
## [77,]  0.84262244
##
## $scores$yscores
##              [,1]        [,2]          [,3]         [,4]         [,5]
##  [1,] -0.31044586 -0.53203634  0.1938426501  1.180179320  0.186438791
##  [2,]  0.38333023 -0.86197250  0.3032046245  0.434070565 -0.037239481
##  [3,]  0.09125773  0.38810355  1.7219500162  0.300039415 -0.114901245
##  [4,]  1.15399696 -0.25942517 -0.1478286016  1.689728526 -1.264875376
##  [5,]  0.93831683 -0.24453146 -0.1271079006  0.548043170 -0.800479109
##  [6,]  1.59766384  0.78992654  0.0118302337  0.869076901 -0.973906563
##  [7,]  0.65348958 -0.40876233  0.4043959922  0.231712782 -0.386012953
##  [8,]  1.24167322  0.56959428 -0.1784372702  0.342484211 -0.045080386
##  [9,]  1.00140567  0.47357385 -0.4731002488  0.995441537  0.596443863
## [10,]  0.56083910 -1.05193930  0.2054115432  0.523716661 -0.488043968
## [11,] -0.02532729 -1.46358944  0.0938631020  0.477199833 -0.762380916
## [12,] -0.45887377 -0.85306630  0.6263846754  0.498066944  0.516107423
## [13,]  0.25713665 -0.33552629  0.7703779897  0.467131417  1.290306572
## [14,]  0.65322336 -1.27098995  0.7701549984 -0.001257793 -0.008833054
## [15,]  0.58579431 -0.69289405 -2.5716842457 -1.359452214 -0.497710990
## [16,]  0.13857423 -0.98008360 -1.2368712092 -2.349999388 -2.081546230
## [17,]  2.34921753  0.94791540 -3.3876848180 -2.521253331 -1.282523499
## [18,]  0.40143910 -2.16992980  0.1455795723 -0.451498744  0.603950103
## [19,]  0.41635485 -1.02491726 -0.1278245591  0.366048442  1.237304351
## [20,]  1.24732098  0.17977020  0.3164802299  0.251775485  1.093770628
## [21,]  0.75700906 -0.13907243 -0.2045349256  0.608113449  1.029154614
## [22,]  0.13924849 -1.58662337 -0.9833310991  1.367702516  1.739004692
## [23,]  0.39290590 -0.68570928 -0.7130444979  1.934881168 -0.486960925
## [24,]  0.12872290  0.80889111  0.1224715273  1.246065989 -1.776430757
## [25,] -0.53210545 -0.40962226  0.8914243164  0.558566066  1.386201271
## [26,]  0.58622057  0.01139887  1.1555313289 -0.573972843  0.387434701
## [27,]  1.99033865  0.49890651  1.3122742669 -1.101863550 -0.705485076
## [28,] -0.42178008 -1.04926092  0.7088204632  0.137718041 -2.727362635
## [29,]  1.23403319 -0.26058948  0.7778832254 -0.991400181  0.529622762
## [30,]  0.19368471 -1.15763718  0.8641867747  0.124495287 -0.362216458
## [31,]  0.77209991 -0.45032595  0.0474376738  0.320739692  1.120815323
## [32,]  0.52210834  0.06246775  0.6257921323 -0.114075987 -0.952244015
## [33,]  1.22684426  0.64623197  0.5217356952  0.150104281 -1.083823590
## [34,] -0.20652416 -0.03520248 -0.6470017176  1.968459765  1.361295265
## [35,]  0.35032924 -0.80599771  0.9521848691  0.870315966 -1.400021821
## [36,] -0.55767356 -1.59686208  0.4574286369  0.192025151 -0.258019027
## [37,]  0.75329432  0.20188139  0.6060851659  0.389037460  0.038213430
```

```
## [38,]  0.96175634  0.11667097  0.2881823546 -0.470675934 -1.177663496
## [39,]  1.99620265 -1.23686922 -0.2304300141  1.508540793 -0.608523861
## [40,]  0.22889447 -1.17329942  1.4348829024 -0.310205402  0.372256662
## [41,]  1.12050566 -0.60378199  0.5980586096  0.049281443  0.752648618
## [42,]  1.02664624 -0.19510361  1.3659755179 -0.712471275  0.773933855
## [43,] -1.24813462  0.39870334 -0.5166264502  0.037961437  0.444683324
## [44,] -0.03799166 -0.48851436 -0.4852846119  0.077619789  0.689826676
## [45,] -2.94736327 -2.08181155  0.0966023142  0.158655608 -1.282653404
## [46,]  0.49633563  0.82326802 -1.2752413421 -0.577399533  0.147796485
## [47,] -0.66546943  0.43300122 -1.5170703174  1.038945731  0.247604276
## [48,]  0.06068239  0.41673474 -0.7525602544 -0.610539209  0.870374940
## [49,]  0.73533642  1.19120459 -1.1444814944  0.133314602  0.110577875
## [50,]  0.70786278  1.27314478 -0.7166919276 -0.350159213 -0.376847735
## [51,] -1.04361115  2.61150640 -0.1667578087  2.613235864 -0.481952866
## [52,] -1.30983690  1.38314883 -0.7111018930  0.446385929 -0.755477684
## [53,] -1.10369058  0.40456982  1.5847024734 -1.186467705  0.219557243
## [54,] -1.22635880 -0.29714106  0.4397442409 -1.102526966 -1.745556657
## [55,] -1.10802963  0.38704972 -0.7131014426  0.216236721  0.880325615
## [56,] -1.65221907 -1.60486097 -2.2381639921  0.099563283  2.047127647
## [57,] -1.60339636 -1.88926947 -0.9715929234 -1.845209409 -0.389694873
## [58,] -0.28496405  0.37624262 -2.4836341110  0.303720714  0.640945220
## [59,] -0.48886270  0.18268052 -0.9494800936 -0.680760181  0.925804725
## [60,]  0.03701975  0.04531648 -0.1053156183 -1.288354605  0.499391318
## [61,]  0.25975085  0.84684333  0.7524963582 -1.393457369  0.461626906
## [62,] -0.62053114  0.46895454  0.6805802336 -0.313611343  0.623221557
## [63,] -0.35810707  0.84619318  0.0650518261 -0.457513765  0.216935528
## [64,] -0.95052254  0.63762861 -0.3237255153 -0.553622540  0.679297626
## [65,] -0.99687872  2.40917989  0.7189642035  0.225761011 -1.775344538
## [66,] -0.33064794  0.89227475 -0.1343209429 -0.621294018  0.115581312
## [67,] -1.01120790  0.94679628 -0.0001612678 -0.348904864  0.180105936
## [68,] -0.41847704  0.45315655 -1.1865871089 -0.572231865  0.300807661
## [69,] -1.72992500 -0.66086282  1.0725862379 -0.835666432 -0.527794711
## [70,] -0.71316383  2.23442936  1.5842698114  0.564829524  1.014722651
## [71,] -0.66299545  1.15300911 -0.0580273660  0.157818635 -1.760031595
## [72,] -0.55974620  0.30757250 -0.5467640073  0.922550376  0.714352584
## [73,] -2.06648191 -0.49674836  0.9670373535 -1.442805648 -1.063833777
## [74,] -1.94403308  0.82422467 -1.3584119561  1.305783109 -0.915082128
## [75,] -0.82675299  0.97033178  1.1213993592 -0.452790237  1.159118540
## [76,] -0.35701692  1.13928316  1.2579362204 -0.316263234  1.042229203
## [77,]  0.43027923  1.30304858  0.7487818320 -2.995439830  2.109637625
##              [,6]
##  [1,] -0.24887557
##  [2,] -0.05733783
##  [3,]  0.23030497
##  [4,]  0.32588875
##  [5,]  0.13781182
##  [6,] -0.09994653
##  [7,]  0.14573074
##  [8,] -1.52098771
##  [9,] -0.67073228
```

```
## [10,] -0.65771459
## [11,] -0.85087561
## [12,]  0.10845314
## [13,] -0.03259888
## [14,] -0.37981480
## [15,]  2.02962313
## [16,]  3.00844842
## [17,]  1.30525725
## [18,] -0.20442144
## [19,] -0.13771986
## [20,] -0.21176606
## [21,] -0.24892462
## [22,] -0.41316909
## [23,] -0.59246971
## [24,] -0.08396876
## [25,]  0.54902259
## [26,] -0.22444257
## [27,] -1.56903697
## [28,] -1.36208381
## [29,] -0.15873041
## [30,]  0.45013942
## [31,]  0.94681445
## [32,] -0.71122141
## [33,] -0.56617684
## [34,]  1.61282322
## [35,]  0.95989027
## [36,] -0.60381980
## [37,] -0.62076245
## [38,] -0.19274292
## [39,]  2.69029975
## [40,]  1.34578743
## [41,]  0.24948206
## [42,] -0.34588997
## [43,] -0.22587145
## [44,] -1.09224521
## [45,] -0.55549468
## [46,] -2.15578749
## [47,] -0.29545978
## [48,] -1.46558385
## [49,] -0.69915111
## [50,] -0.79706014
## [51,]  2.00006787
## [52,]  0.11277907
## [53,]  0.28565532
## [54,] -0.36335967
## [55,] -0.48190968
## [56,]  0.33426370
## [57,]  1.64771981
## [58,]  0.20268403
## [59,] -1.65685609
```

```
## [60,] -0.98334135
## [61,]  0.47477796
## [62,]  0.70601872
## [63,] -0.65515614
## [64,] -1.00359887
## [65,] -0.03645915
## [66,]  0.10191778
## [67,]  0.18682306
## [68,] -1.28549001
## [69,]  0.43069353
## [70,]  2.68537116
## [71,]  0.38910834
## [72,]  0.58405515
## [73,] -0.86189551
## [74,] -1.01260997
## [75,]  0.47522467
## [76,]  1.12755537
## [77,]  0.55306766
##
## $scores$corr.X.xscores
##               [,1]        [,2]        [,3]       [,4]        [,5]
## log.ca -0.83594307  0.21697553  0.36131209 -0.1600025 -0.17237139
## log.p  -0.24345807 -0.58474288 -0.24500255  0.6733891  0.16490482
## log.mg -0.29337933  0.42943787 -0.44030550  0.4019760 -0.04109757
## log.na -0.62062808 -0.07702895 -0.27566174 -0.3957764  0.37713242
## log.k  -0.71336659  0.25789930 -0.27189193 -0.1663798 -0.49808038
## cl      0.06687427 -0.69658305 -0.04512222 -0.2654131 -0.44799203
##              [,6]
## log.ca  0.2612693
## log.p  -0.2411041
## log.mg  0.6102205
## log.na  0.4837666
## log.k  -0.2736869
## cl      0.4869526
##
## $scores$corr.Y.xscores
##                          [,1]        [,2]        [,3]        [,4]
## glucose           -0.3427459 -0.44933516 -0.06668355  0.06292355
## urea.nitrogen      0.6247861 -0.20400273  0.02735553  0.10164617
## log.uric.acid     -0.3723539  0.20864570 -0.15678520  0.09076967
## cholesterol       -0.3587584 -0.02174311 -0.02824320  0.21467036
## log.total.protein -0.6014485 -0.01174406  0.16354016  0.03902177
## log.albumin       -0.4449361 -0.04452893 -0.20585619 -0.10877130
##                          [,5]         [,6]
## glucose           -0.01444461 -0.005655459
## urea.nitrogen     -0.06571880  0.011390436
## log.uric.acid     -0.08636851 -0.050625556
## cholesterol        0.06153961  0.044791467
## log.total.protein -0.07726309  0.039299843
## log.albumin       -0.02786058  0.058512624
```

```
##
## $scores$corr.X.yscores
##               [,1]        [,2]        [,3]        [,4]         [,5]
## log.ca -0.66329688  0.11330379  0.16566091 -0.04792060 -0.036520127
## log.p  -0.19317701 -0.30535048 -0.11233321  0.20167938  0.034938194
## log.mg -0.23278810  0.22425080 -0.20187925  0.12039140 -0.008707294
## log.na -0.49245060 -0.04022422 -0.12639039 -0.11853466  0.079902609
## log.k  -0.56603595  0.13467402 -0.12466194 -0.04983058 -0.105527713
## cl      0.05306282 -0.36375299 -0.02068845 -0.07949097 -0.094915553
##               [,6]
## log.ca  0.02671279
## log.p  -0.02465105
## log.mg  0.06239038
## log.na  0.04946143
## log.k  -0.02798239
## cl      0.04978718
##
## $scores$corr.Y.yscores
##                         [,1]        [,2]        [,3]       [,4]
## glucose           -0.4319575 -0.86047198 -0.14543909  0.2100960
## urea.nitrogen      0.7874085 -0.39066303  0.05966335  0.3393873
## log.uric.acid     -0.4692721  0.39955427 -0.34195386  0.3030717
## cholesterol       -0.4521378 -0.04163782 -0.06159938  0.7167648
## log.total.protein -0.7579965 -0.02248975  0.35668664  0.1302901
## log.albumin       -0.5607463 -0.08527242 -0.44897934 -0.3631775
##                         [,5]        [,6]
## glucose           -0.06817714 -0.05531425
## urea.nitrogen     -0.31018624  0.11140625
## log.uric.acid     -0.40765082 -0.49515254
## cholesterol        0.29046088  0.43809116
## log.total.protein -0.36467415  0.38437932
## log.albumin       -0.13149917  0.57229345
```

Question: what is the first canonical correlation (report the number)? What is it the correlation between?

0.79, and it is the correlation between an axis through the ions with an axis through the big.molecules.

Question: interpret the first canonical correlation axis for ions - use the corr.X.xscores loadings to interpret what the first axis tells us about blood ions.

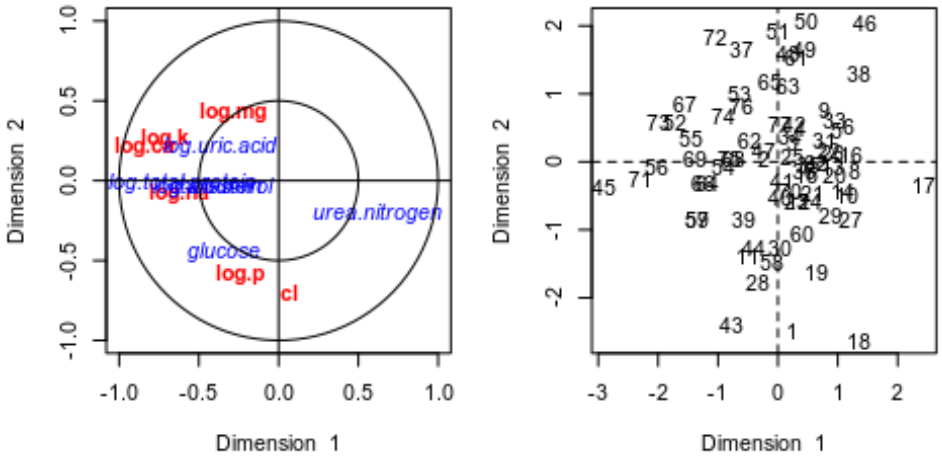
It is primarily a measure of total ion concentration, because all but one ion has the same sign, and the one with a different sign (cl) is close to zero.

Question: interpret the first canonical correlation axis for big molecules - use the corr.Y.yscores loadings to interpret what the first axis tells us about the blood big moleculres.

It is a trade-off between urea.nitrogen and the other big molecules.

Plot the CCA results:

```
plt.cc(blood.cc, var.label=T)
```



Question: what does the plot on the left showing the ions (in red) and the big molecules (in blue) tell you about the way that ions and big molecules are related?

The ions and big molecules are mostly positively correlated, except for cl and urea.nitrogen. The second CC axis also shows that there is a trade-off between cl, log.p and glucose against log.mg and log.uric.acid.

Question: animal number 45 is at the far left of the graph on the right side, in which the turtles are plotted accourding to their scores. What would you expect the blood chemistry would be like for this animal (as in, which substances would be at high levels, and which would be at low levels)?

That animal should have high levels of ca, total protein, k, and all of the other substances on the left side of the graph.

Question: animal number 1 is at the bottom of the graph, what would you expect its blood chemistry to be like?

The animal at the bottom of the graph should have high levels of cl, glucose, and phosphorus.

Calculate communalities for ions:

```
ones.matrix <- round(upper.tri(matrix(nrow = 6, ncol = 6), diag = T))

blood.cc$scores$corr.X.xscores^2 %*% ones.matrix -> ions.communalities

ions.communalities
```

```
##               [,1]      [,2]      [,3]      [,4]      [,5] [,6]
## log.ca 0.698800824 0.7458792 0.8764256 0.9020264 0.9317383    1
## log.p  0.059271834 0.4011961 0.4612223 0.9146752 0.9418688    1
## log.mg 0.086071434 0.2704883 0.4643573 0.6259419 0.6276309    1
## log.na 0.385179211 0.3911127 0.4671021 0.6237411 0.7659699    1
## log.k  0.508891898 0.5754039 0.6493292 0.6770114 0.9250955    1
## cl     0.004472168 0.4897001 0.4917361 0.5621803 0.7628771    1
```

Question: which ion is least well represented by the first axis? Which is the best represented?

cl has the lowest communality on the first axis.

Calculate communalities for big molecules:

```
blood.cc$scores$corr.Y.yscores^2 %*% ones.matrix ->
big.molecules.communalities

big.molecules.communalities
```

```
##                      [,1]      [,2]      [,3]      [,4]      [,5] [,6]
## glucose           0.1865873 0.9269993 0.9481519 0.9922922 0.9969403    1
## urea.nitrogen     0.6200121 0.7726297 0.7761894 0.8913731 0.9875886    1
## log.uric.acid     0.2202163 0.3798599 0.4967923 0.5886448 0.7548240    1
## cholesterol       0.2044286 0.2061623 0.2099568 0.7237086 0.8080761    1
## log.total.protein 0.5745586 0.5750644 0.7022898 0.7192653 0.8522525    1
## log.albumin       0.3144364 0.3217078 0.5232903 0.6551882 0.6724802    1
```

Question: which big molecule is least well represented, and which is best represented by the first axis?

Log.albumin has the lowest communality.

Calculate redundancy coefficients

Redundancy is a measure of how much variation in ions is shared with big molecules, and vice versa.

The redundancy values are not the same for both data sets, so start with ions:

```
colMeans(blood.cc$scores$corr.X.yscores^2) * blood.cc$cor^2 -> ion.redundancy

ion.redundancy
```

```
## [1] 1.151313e-01 1.401786e-02 3.950768e-03 1.200741e-03 2.181554e-04
## [6] 1.902888e-05
```

```
sum(ion.redundancy)
```

```
## [1] 0.1345378
```

Question: for the first CCA axis, what percentage of the variation in ions is shared with big molecules?

The redundancy coefficient is 0.115, so 11.5%.

Calculate the redundancy for big molecules:

```
colMeans(blood.cc$scores$corr.Y.xscores^2) * blood.cc$cor^2 ->
big.molecule.redundancy

big.molecule.redundancy

## [1] 1.400744e-01 1.316386e-02 3.493040e-03 1.225413e-03 1.684815e-04
## [6] 1.689835e-05

sum(big.molecule.redundancy)

## [1] 0.158142
```

Question: for the first CCA axis, what percentage of the variation in big molecules is shared with ions?

The redundancy coefficient is 0.14, so 14%.