Cancer

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This is part of the online course Proteomics Data Analysis (PDA)

1 Background

Eighteen Estrogen Receptor Positive Breast cancer tissues from from patients treated with tamoxifen upon recurrence have been assessed in a proteomics study. Nine patients had a good outcome (OR) and the other nine had a poor outcome (PD). The proteomes have been assessed using an LTQ-Orbitrap and the thermo output .RAW files were searched with MaxQuant (version 1.4.1.2) against the human proteome database (FASTA version 2012-09, human canonical proteome).

2 Data

We first import the data from peptide.txt file. This is the file containing your peptide-level intensities. For a MaxQuant search [6], this peptide.txt file can be found by default in the "path_to_raw_files/combined/txt/" folder from the MaxQuant output, with "path to raw files" the folder where the raw files were saved.

We generate the object peptideFile with the path to the peptide.txt file. Using the grepEcols function, we find the columns that contain the expression data of the peptide in the peptide.txt file.

```
library(tidyverse)
library(limma)
library(QFeatures)
```

```
library(msqrob2)
library(plotly)

peptidesFile <- "https://raw.githubusercontent.com/statOmics/PDA22GTPB/data/quantification/cancer/peptidecols <- grep(
   "Intensity\\.",
   names(read.delim(peptidesFile))
   )</pre>
```

Next, we read the data and store it in QFeatures object

```
pe <- readQFeatures(
  assayData = read.delim(peptidesFile),
  fnames = 1,
  quantCols = ecols,
  name = "peptideRaw")</pre>
```

```
## Checking arguments.
```

- ## Loading data as a 'SummarizedExperiment' object.
- ## Formatting sample annotations (colData).
- ## Formatting data as a 'QFeatures' object.

The QFeatures object pe currently contains a single assay, named peptideRaw.

We extract the column names from the peptideRaw assay and see that this contains information about the prognosis.

```
colnames(pe[["peptideRaw"]])
```

```
## [1] "Intensity.OR.01" "Intensity.OR.04" "Intensity.OR.07" "Intensity.OR.09"
## [5] "Intensity.OR.10" "Intensity.OR.13" "Intensity.OR.20" "Intensity.OR.23"
## [9] "Intensity.OR.25" "Intensity.PD.02" "Intensity.PD.03" "Intensity.PD.04"
## [13] "Intensity.PD.06" "Intensity.PD.07" "Intensity.PD.08" "Intensity.PD.09"
## [17] "Intensity.PD.10" "Intensity.PD.11"
```

We rename the colnames by dropping the "Intensity." from the name.

```
(newNames <- sub(
  pattern = "Intensity\\.",
  replacement = "",
  colnames(pe[["peptideRaw"]]))
)</pre>
```

```
## [1] "OR.01" "OR.04" "OR.07" "OR.09" "OR.10" "OR.13" "OR.20" "OR.23" "OR.25" ## [10] "PD.02" "PD.03" "PD.04" "PD.06" "PD.07" "PD.08" "PD.09" "PD.10" "PD.11"
```

In the following code chunk, we add the prognosis of the patients that we can read in the raw file name to the colData.

```
colData(pe)$prognosis <-
  colnames(pe[["peptideRaw"]]) %>%
  substr(start = 1, stop = 2) %>%
  as.factor
colData(pe)$prognosis
```

We calculate how many non zero intensities we have per peptide and this will be useful for filtering.

```
rowData(pe[["peptideRaw"]])$nNonZero <- rowSums(assay(pe[["peptideRaw"]]) > 0)
```

Peptides with zero intensities are missing peptides and should be represent with a NA value rather than 0.

```
pe <- zeroIsNA(pe, "peptideRaw") # convert 0 to NA
```

Look at the column names of the data to know the variables that you can use for filtering.

```
pe[["peptideRaw"]] %>% rowData %>% names
```

```
[1] "Sequence"
                                  "Proteins"
                                                            "Leading.razor.protein"
##
                                  "Protein.names"
##
    [4] "Gene.names"
                                                            "Unique..Groups."
   [7] "Unique..Proteins."
                                  "Charges"
                                                            "PEP"
##
                                  "Slice.Average"
## [10] "Score"
                                                            "Slice.Std..Dev."
## [13] "Slice.1"
                                  "Unique.Slice.Average"
                                                            "Unique.Slice.Std..Dev."
## [16] "Unique.Slice.1"
                                  "Experiment.OR.01"
                                                            "Experiment.OR.04"
## [19] "Experiment.OR.07"
                                  "Experiment.OR.09"
                                                            "Experiment.OR.10"
## [22] "Experiment.OR.13"
                                  "Experiment.OR.20"
                                                            "Experiment.OR.23"
## [25] "Experiment.OR.25"
                                  "Experiment.PD.02"
                                                            "Experiment.PD.03"
## [28] "Experiment.PD.04"
                                  "Experiment.PD.06"
                                                            "Experiment.PD.07"
## [31] "Experiment.PD.08"
                                  "Experiment.PD.09"
                                                            "Experiment.PD.10"
                                  "Intensity"
                                                            "Reverse"
## [34] "Experiment.PD.11"
                                  "id"
## [37] "Contaminant"
                                                            "Protein.group.IDs"
## [40] "Mod..peptide.IDs"
                                                            "MS.MS.IDs"
                                  "Evidence.IDs"
## [43] "Best.MS.MS"
                                  "Oxidation..M..site.IDs" "nNonZero"
```

So we will filter on the "Reverse", "Contaminant" and "nNonZero" column.

2.1 Data exploration

47% of all peptide intensities are missing and for some peptides we do not even measure a signal in any sample.

3 Preprocessing

This section preforms preprocessing for the peptide data. This include

- log transformation,
- filtering and
- summarisation of the data.

3.1 Log transform the data

```
pe <- logTransform(pe, base = 2, i = "peptideRaw", name = "peptideLog")</pre>
```

3.2 Filtering

1. Handling overlapping protein groups

In our approach a peptide can map to multiple proteins, as long as there is none of these proteins present in a smaller subgroup.

```
pe <- filterFeatures(pe, ~ Proteins %in% smallestUniqueGroups(rowData(pe[["peptideLog"]])$Proteins))</pre>
```

'Proteins' found in 2 out of 2 assay(s)

2. Remove reverse sequences (decoys) and contaminants

We now remove the contaminants and peptides that map to decoy sequences.

```
pe <- filterFeatures(pe,~Reverse != "+")

## 'Reverse' found in 2 out of 2 assay(s)
pe <- filterFeatures(pe,~ Contaminant != "+")</pre>
```

'Contaminant' found in 2 out of 2 assay(s)

3. Drop peptides that were only identified in one sample

We keep peptides that were observed at last twice.

```
pe <- filterFeatures(pe,~ nNonZero >=2)
## 'nNonZero' found in 2 out of 2 assay(s)
nrow(pe[["peptideLog"]])
```

[1] 26696

We keep 26696 peptides upon filtering.

3.3 Normalize the data using median centering

We normalize the data by substracting the sample median from every intensity for peptide p in a sample i:

$$y_{ip}^{\text{norm}} = y_{ip} - \hat{\mu}_i$$

with $\hat{\mu}_i$ the median intensity over all observed peptides in sample i.

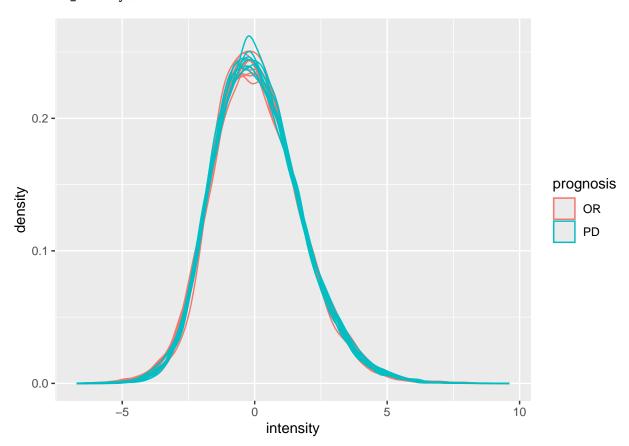
3.4 Explore normalized data

Upon the normalisation the density curves are nicely registered

```
pe[["peptideNorm"]] %>%
  assay %>%
  as.data.frame() %>%
```

```
gather(sample, intensity) %>%
mutate(prognosis = colData(pe)[sample,"prognosis"]) %>%
ggplot(aes(x = intensity,group = sample,color = prognosis)) +
   geom_density()
```

 $\mbox{\tt \#\#}$ Warning: Removed 188395 rows containing non-finite outside the scale range $\mbox{\tt \#\#}$ ('stat_density()').



We can visualize our data using a Multi Dimensional Scaling plot, eg. as provided by the limma package.

```
pe[["peptideNorm"]] %>%
  assay %>%
  limma::plotMDS(col = as.numeric(colData(pe)$prognosis))
```



The first axis in the plot is showing the leading log fold changes (differences on the log scale) between the samples. We observe one outlying sample. In the second dimension we observe a separation according to prognosis.

3.5 Summarization to protein level

• By default robust summarization is used: fun = MsCoreUtils::robustSummary()

```
pe <- aggregateFeatures(pe,
   i = "peptideNorm",
   fcol = "Proteins",
   na.rm = TRUE,
   name = "protein")</pre>
```

```
## Your quantitative and row data contain missing values. Please read the ## relevant section(s) in the aggregateFeatures manual page regarding the ## effects of missing values on data aggregation.
```

```
plotMDS(assay(pe[["protein"]]), col = as.numeric(colData(pe)$prognosis))
```



Note that the samples upon robust summarisation show a separation according to the prognosis.

4 Data Analysis

4.1 Estimation

We model the protein level expression values using msqrob. By default msqrob2 estimates the model parameters using robust regression.

We will model the data with a different group mean. The group is incoded in the variable prognosis of the colData. We can specify this model by using a formula with the factor condition as its predictor: formula = ~prognosis.

Note, that a formula always starts with a symbol '~'.

```
pe <- msqrob(object = pe, i = "protein", formula = ~prognosis)</pre>
```

4.2 Inference

First, we extract the parameter names of the model by looking at the first model. The models are stored in the row data of the assay under the default name msqrobModels.

```
getCoef(rowData(pe[["protein"]])$msqrobModels[[1]])
## (Intercept) prognosisPD
## -1.1185468  0.4007461
```

We can also explore the design of the model that we specified using the the package ExploreModelMatrix

```
library(ExploreModelMatrix)
VisualizeDesign(colData(pe),~prognosis)$plotlist
```

[[1]]

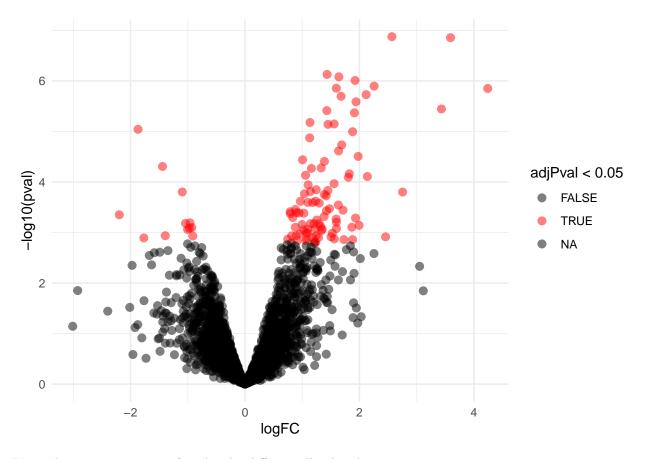


Spike-in condition A is the reference class. So the mean $\log 2$ expression for samples from good prognosis (OR) is '(Intercept). The mean $\log 2$ expression for samples from poor prognosis (PD) is '(Intercept)+prognosisPD'. Hence, the average $\log 2$ fold change between prognosis PD and prognosis OR is modelled using the parameter 'conditionPD'. Thus, we assess the contrast 'conditionPD = 0' with our statistical test.

```
L <- makeContrast("prognosisPD=0", parameterNames = c("prognosisPD"))
pe <- hypothesisTest(object = pe, i = "protein", contrast = L)</pre>
```

4.3 Plots

4.3.1 Volcano-plot

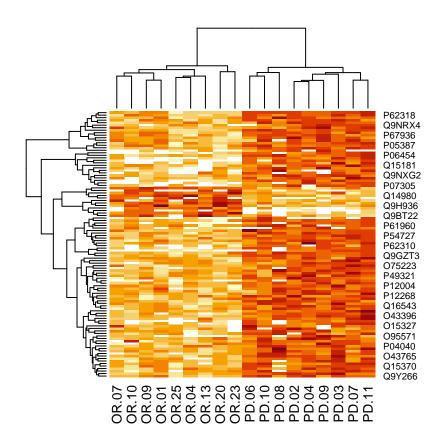


Note, that 106 proteins are found to be differentially abundant.

4.3.2 Heatmap

Note, that we also order the sigNames according to statistical significance.

```
sigNames <- rowData(pe[["protein"]])$prognosisPD %>%
  rownames_to_column("protein") %>%
  arrange(pval) %>%
  filter(adjPval<0.05) %>%
  pull(protein)
heatmap(assay(pe[["protein"]])[sigNames, ])
```

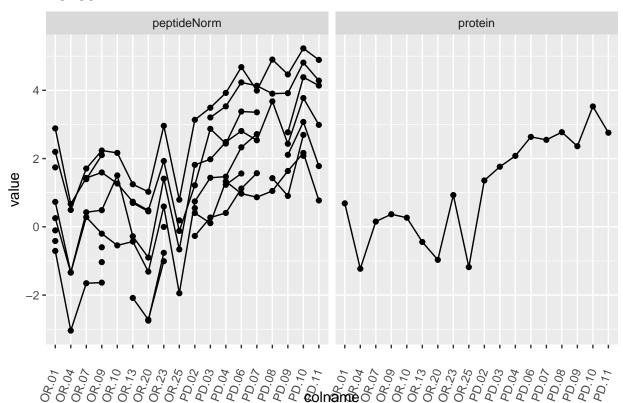


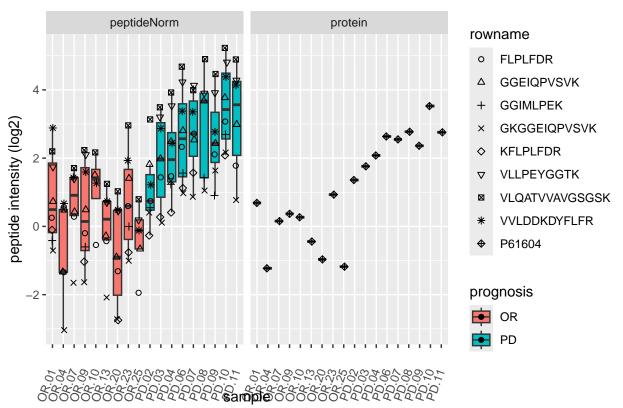
4.3.3 Detail plots

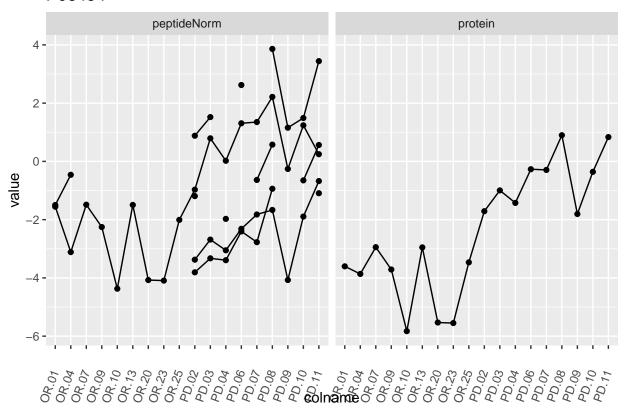
We make detail plots for the top 10 proteins to restrict the number of detail plots.

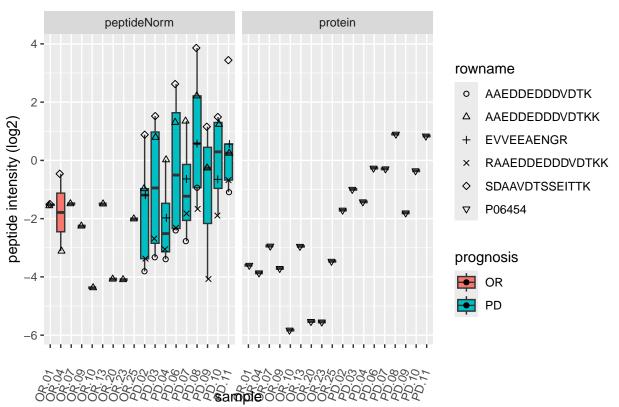
```
for (protName in sigNames)
#for (protName in orderProt[1:10])
pePlot <- pe[protName, , c("peptideNorm", "protein")]</pre>
pePlotDf <- data.frame(longFormat(pePlot))</pre>
pePlotDf$assay <- factor(pePlotDf$assay,</pre>
                         levels = c("peptideNorm", "protein"))
pePlotDf$prognosis <- as.factor(colData(pePlot)[pePlotDf$colname, "prognosis"])</pre>
# plotting
p1 <- ggplot(data = pePlotDf,</pre>
       aes(x = colname, y = value, group = rowname)) +
    geom_line() +
    geom_point() +
    theme(axis.text.x = element_text(angle = 70, hjust = 1, vjust = 0.5)) +
    facet_grid(~assay) +
    ggtitle(protName)
print(p1)
# plotting 2
p2 <- ggplot(pePlotDf, aes(x = colname, y = value, fill = prognosis)) +</pre>
  geom_boxplot(outlier.shape = NA) +
```

```
geom_point(
   position = position_jitter(width = .1),
   aes(shape = rowname)) +
   scale_shape_manual(values = 1:nrow(pePlotDf)) +
   labs(title = protName, x = "sample", y = "peptide intensity (log2)") +
   theme(axis.text.x = element_text(angle = 70, hjust = 1, vjust = 0.5)) +
   facet_grid(~assay)
print(p2)
}
```





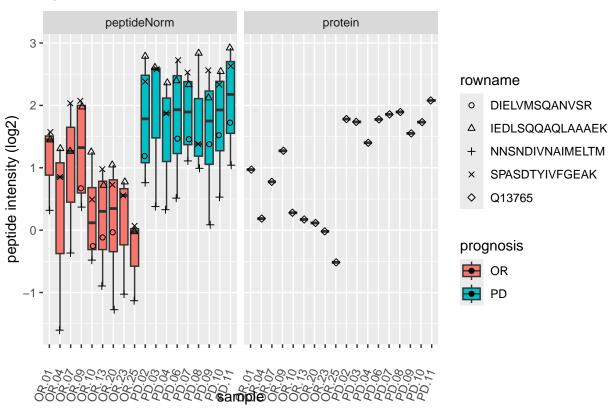




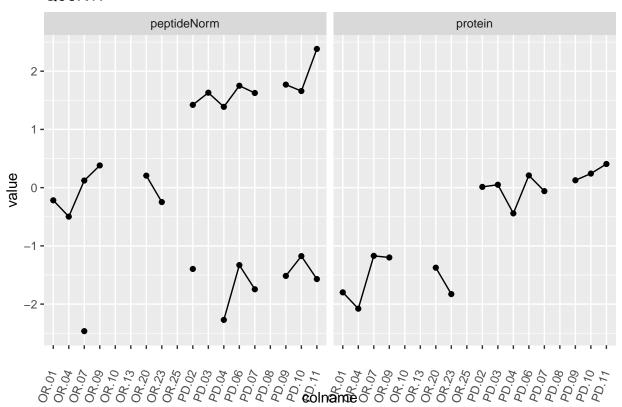
Q13765



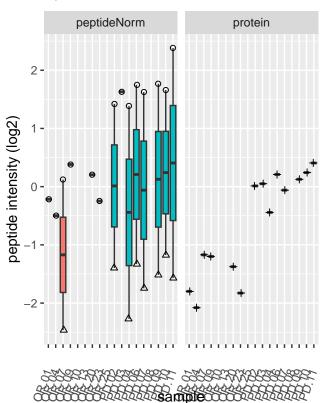
Q13765



Q96K17



Q96K17



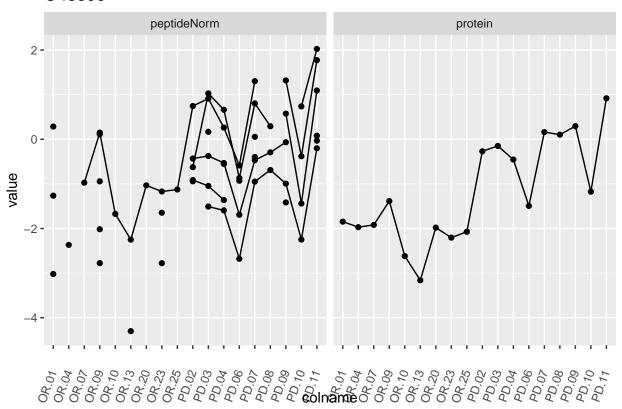
prognosis



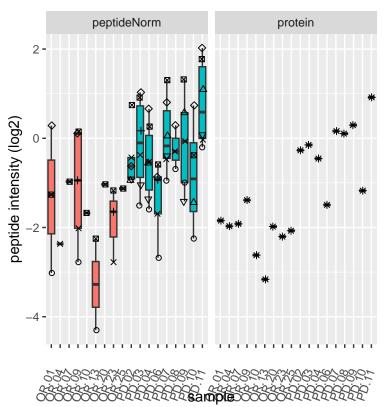
rowname

- APKPEDIDEEDDDVPDLVENFDEASKNEAN
- △ LAEQFPR
- + Q96K17

O43396



O43396

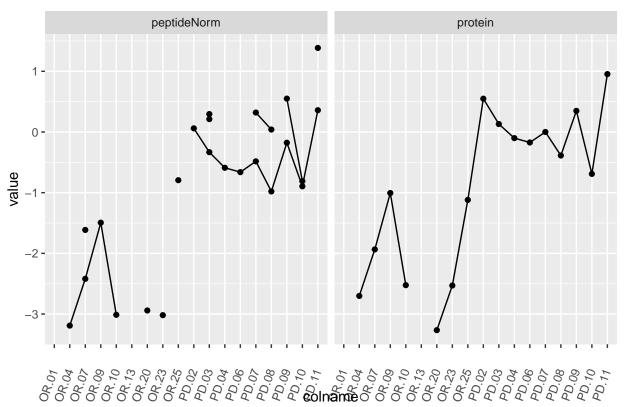


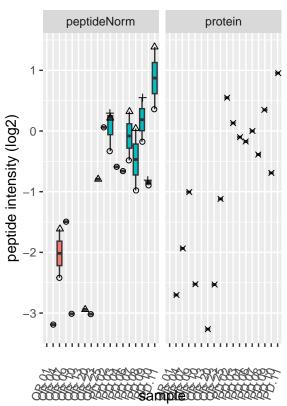
rowname

- FQGPDNGQGPK
- FQNVNSVTIFVQSNQGEEETTR
- IDQYQGADAVGLEEK +
- QHLENDPGSNEDTDIPK ×
- SEPTQALELTEDDIKEDGIVPLR \Diamond
- SMDFEEAER
- VGVKPVGSDPDFQPELSGAGSR
- O43396

prognosis







rowname

- AAATPESQEPQAK
- GDVTAEEAAGASPAK
- GEGESPPVNGTDEAAGATGDAIEPAPPSQGAEAK
- P49006

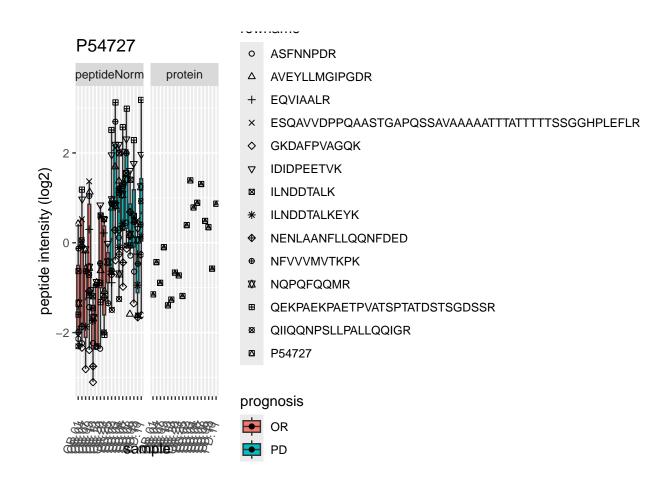
prognosis

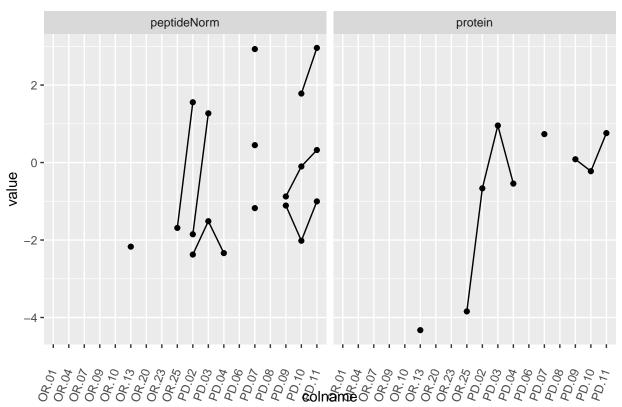


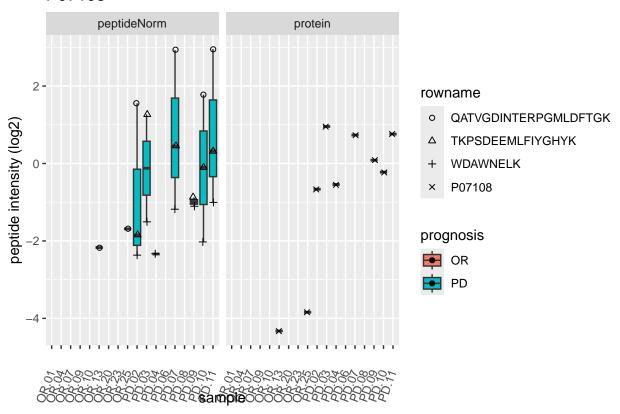


PD

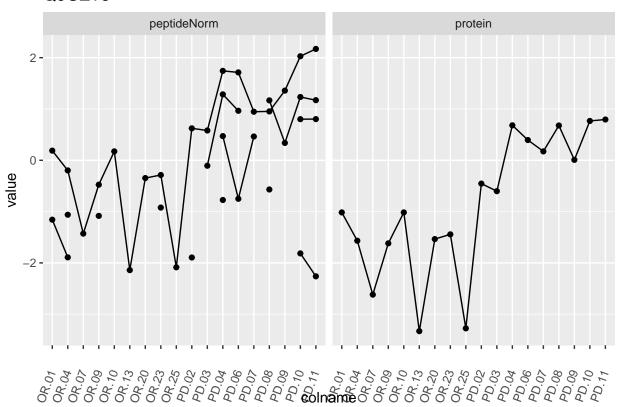




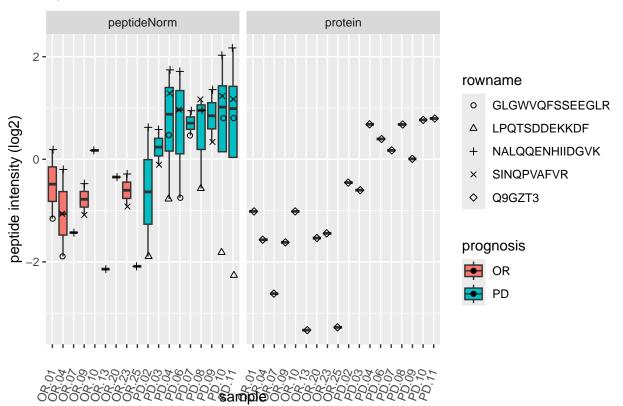




Q9GZT3



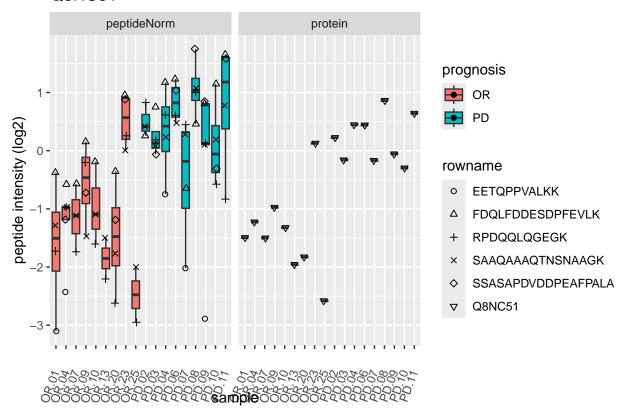
Q9GZT3



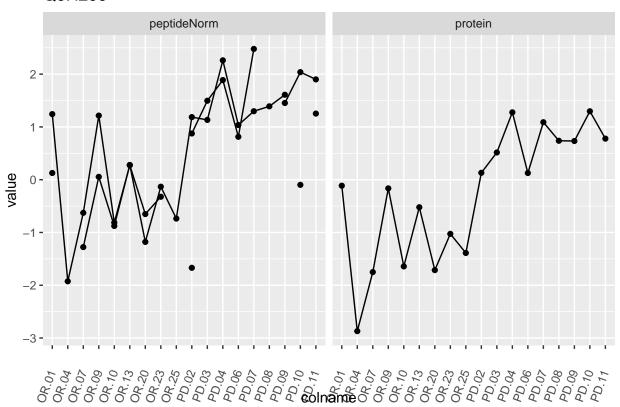
Q8NC51



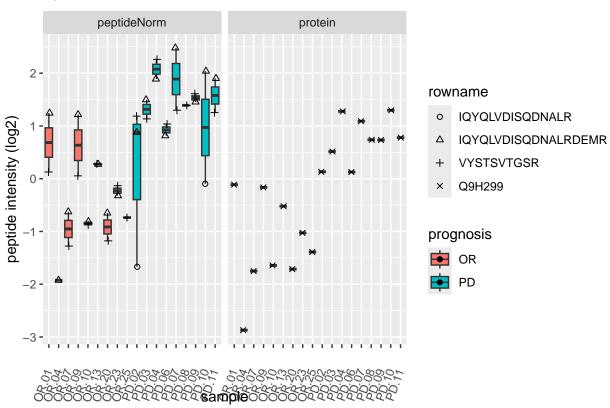
Q8NC51



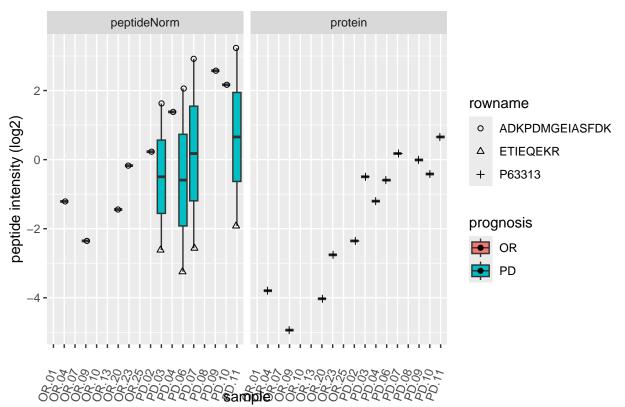
Q9H299



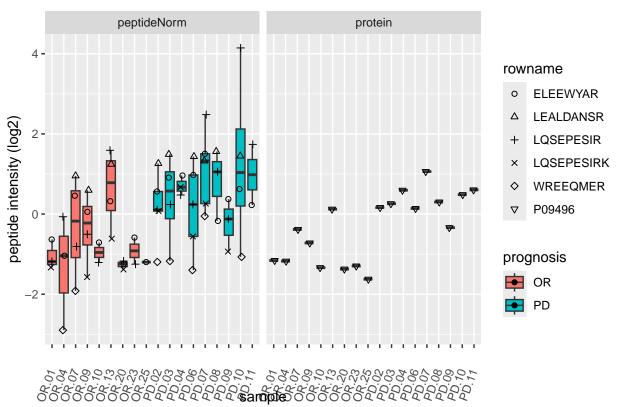
Q9H299

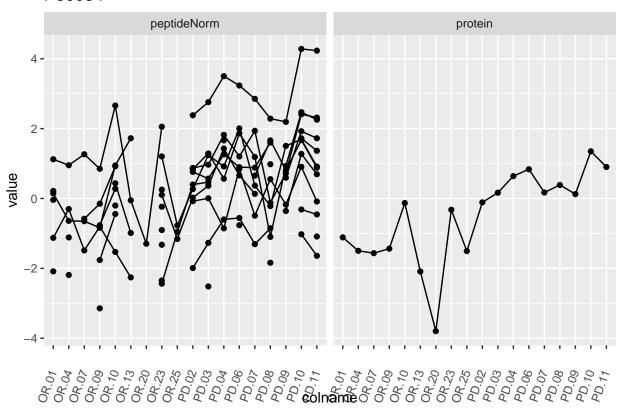


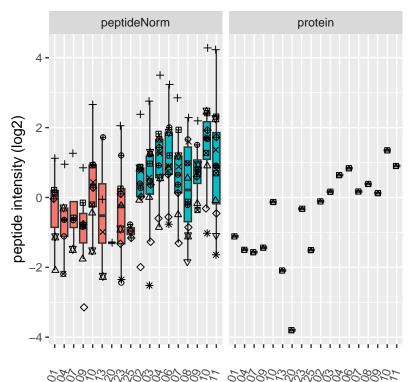












J

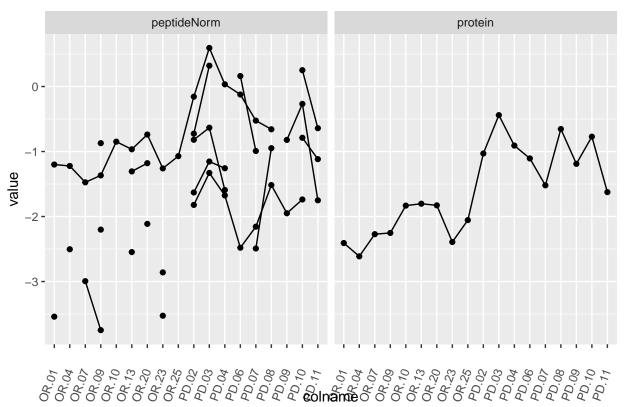
- AFAAGADIK
- △ ALNALCDGLIDELNQALK
- + AQFAQPEILIGTIPGAGGTQR
- × EGMTAFVEK
- ♦ EMQNLSFQDCYSSK
- ▼ ESVNAAFEMTLTEGSK
- GKNNTVGLIQLNRPK
- * ICPVETLVEEAIQCAEK
- ♦ KLFYSTFATDDRK
- ⊕ LFYSTFATDDRK
- SLAMEMVLTGDR
- ▼ TFEEDPAVGAIVLTGGDK
- P30084

prognosis

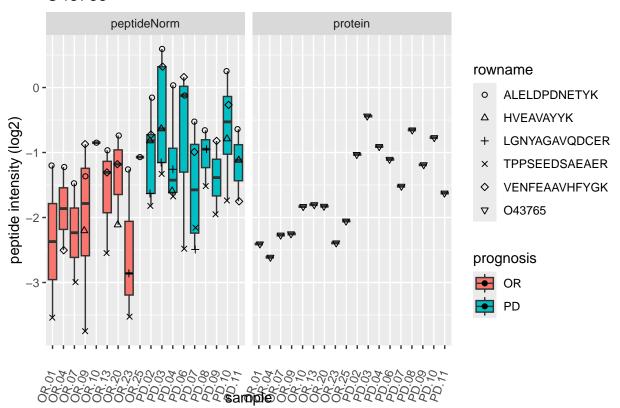


PD

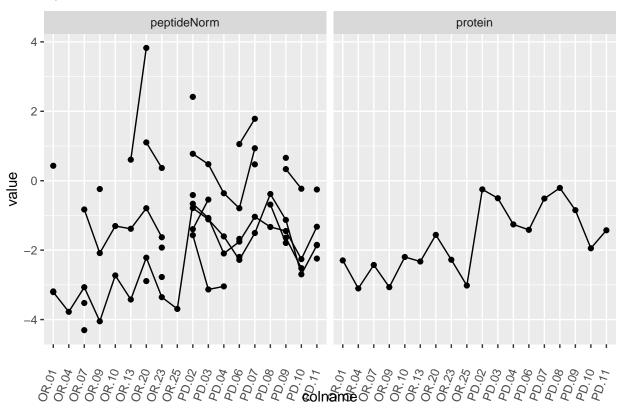
O43765



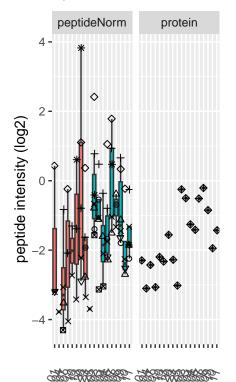
O43765



Q9NXG2



Q9NXG2



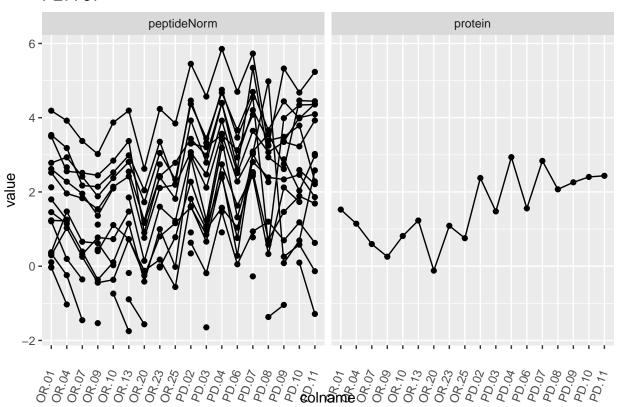
rowname

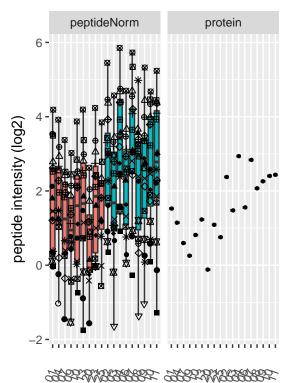
- AAPAQQTTQPGGGK
- △ AAPAQQTTQPGGGKR
- + FQSVESGANNVVFIR
- × LESADKSDQNNTAEGK
- ♦ NNQQVPENTEELGQTKPTSNPQVVNEGGAKPELASQATEGSK
- ∇ NNSHVNREEVIR
- SPKDPSQLNSK
- * YNLQEVVK
- ◆ Q9NXG2

prognosis



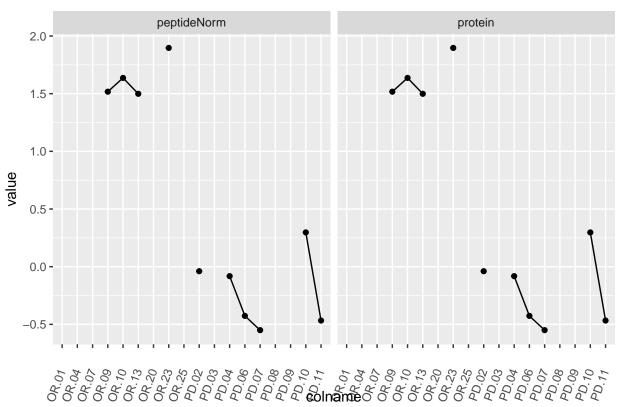
PD



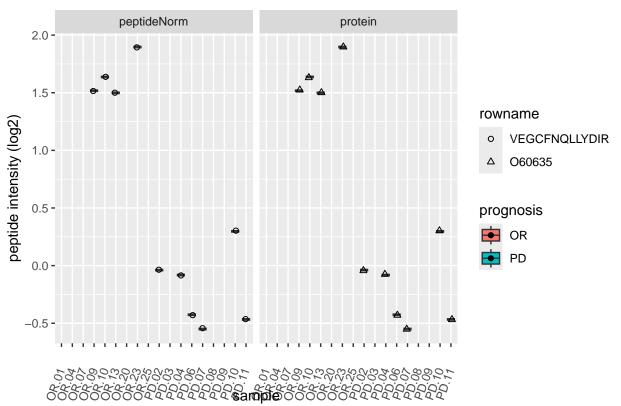


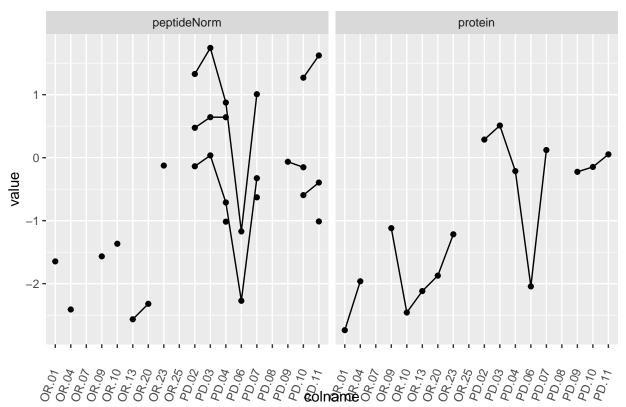
- I IALOAOI LI I ONN
- × FYGDEEKDK
- ♦ FYGDEEKDKGLQTSQDAR
- ∇ GKNVLINK
- GQTLVVQFTVK
- * GTWIHPEIDNPEYSPDPSIYAYDNFGVLGLDLWQVK
- ♦ HEQNIDCGGGYVK
- IDDPTDSKPEDWDKPEHIPDPDAK
- ☆ IDNSQVESGSLEDDWDFLPPK
- IDNSQVESGSLEDDWDFLPPKK
- IKDPDASKPEDWDER
- KPEDWDEEMDGEWEPPVIQNPEYK
- KVHVIFNYK
- LFPNSLDQTDMHGDSEYNIMFGPDICGPGTK
- ▲ QIDNPDYK
- SGTIFDNFLITNDEAYAEEFGNETWGVTK
- VHVIFNYK
- P27797

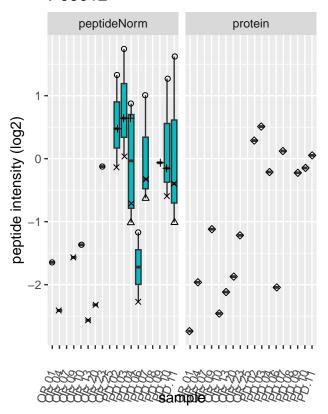
O60635



O60635







rowname

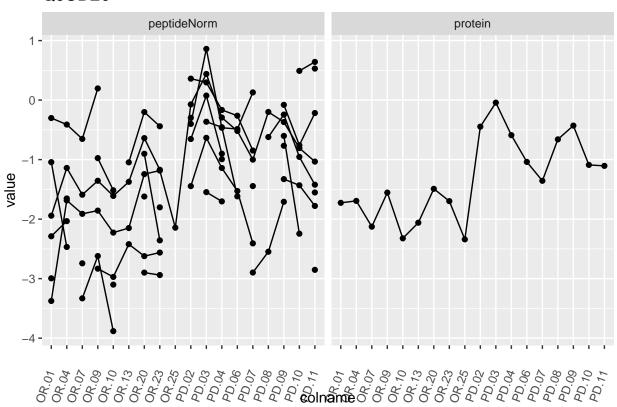
- AVPETRPNHTIYINNLNEK
- △ AVQGGGATPVVGAVQGPVPGMPPMTQAPR
- + EVSSATNALR
- × HDIAFVEFDNEVQAGAAR
- ♦ P09012

prognosis

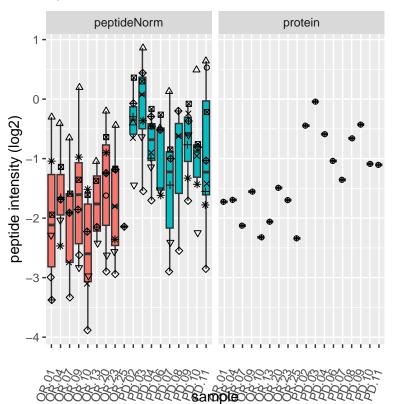


喜 PD

Q9UBE0



Q9UBE0



rowname

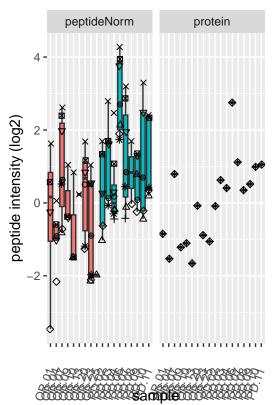
- AQNLNPMVDVK
- △ GLTMLDHEQVTPEDPGAQFLIR
- + LWGLEAQK
- × NDVLDSLGISPDLLPEDFVR
- ♦ NRAEASLER
- ▼ TTSDYFLLQVLLK
- VEKEEAGGGISEEEAAQYDR
- * VLLVGLKGLGAEIAKNLILAGVK
- ♦ VSQGVEDGPDTKR
- ⊕ Q9UBE0

prognosis



OR





rowname

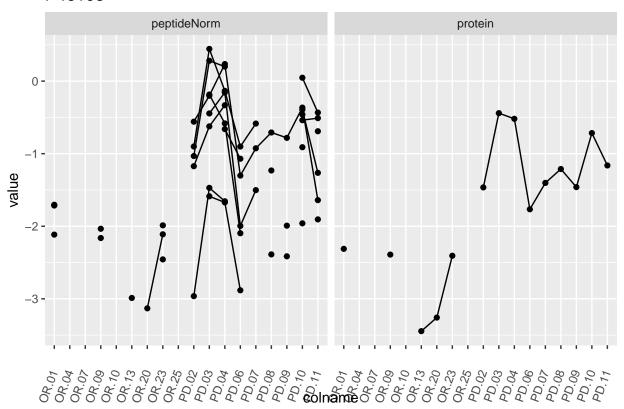
- ASAAFSSVGSVITK
- ELAKVEEEIQTLSQVLAAK Δ
- SFEEKVENLK
- TDPVPEEGEDVAATISATETLSEEEQEELRR ×
- **TSETLSQAGQK** \Diamond
- VEEEIQTLSQVLAAK ∇
- VGGTKPAGGDFGEVLNSAANASATTTEPLPEK
- VGGTKPAGGDFGEVLNSAANASATTTEPLPEKTQESL
- P55327

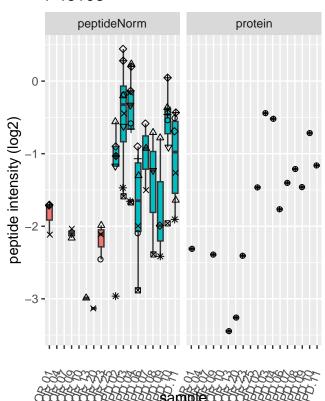
prognosis





PD





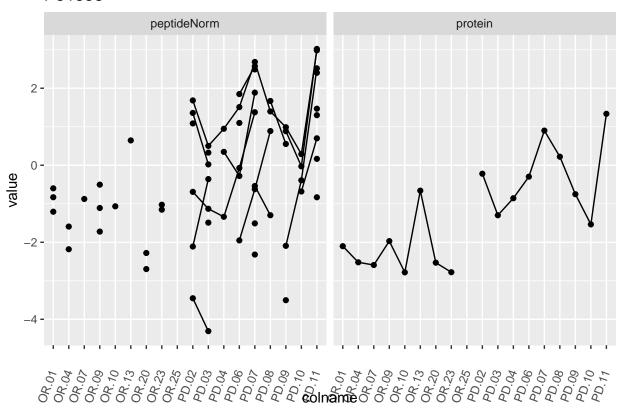
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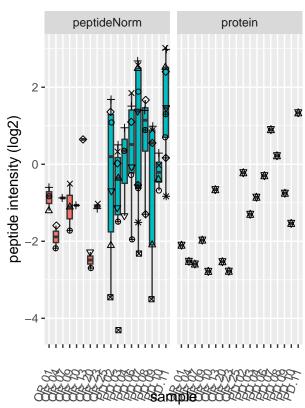
- ALFDFNGNDEEDLPFK
- △ DSSTSPGDYVLSVSENSR
- + HGVFLVR
- × IGDQEFDSLPALLEFYK
- ♦ IHYLDTTTLIEPVSR
- ▽ QEAVALLQGQR
- QGSGVILR
- * TALALEVGELVK
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- Ф P46108

prognosis









rowname

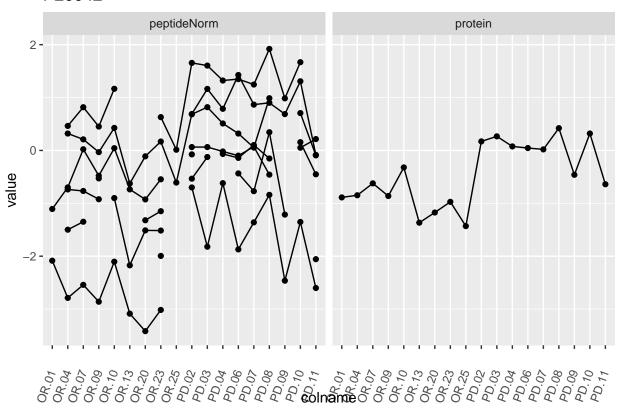
- EAENPEGEEKEAATLEVERPLPMEVEK
- △ GFSEGLWEIENNPTVK
- + GPPQEEEEEEDEEEEATKEDAEAPGIR
- × GPPQEEEEEEDEEEEATKEDAEAPGIRDHESL
- ♦ IDEMPEAAVK
- NSTPSEPGSGR
- * RAGDLLEDSPK
- ◆ SCVEEPEPEPEAAEGDGDKK
- ⊕ YQVFFFGTHETAFLGPK

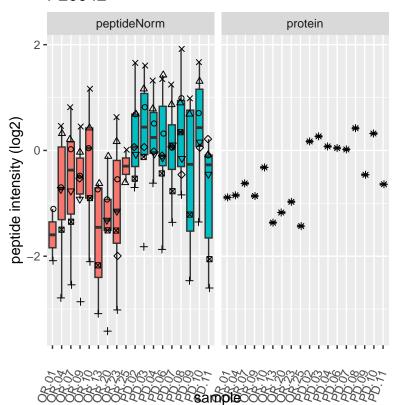
prognosis



OR







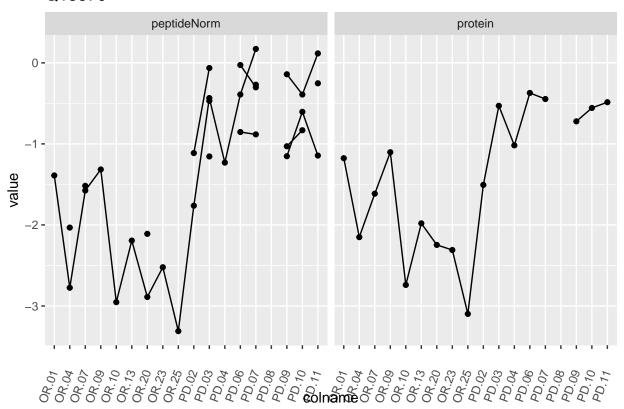
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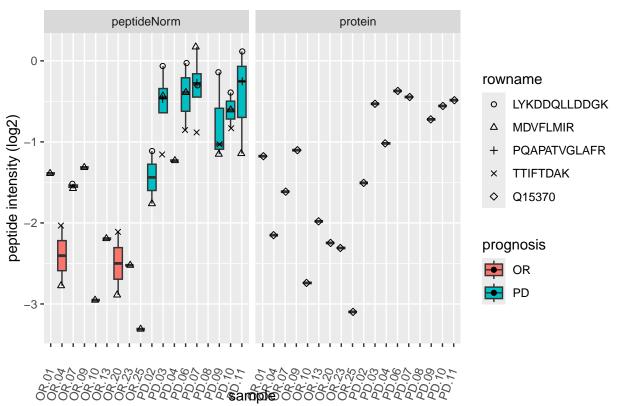


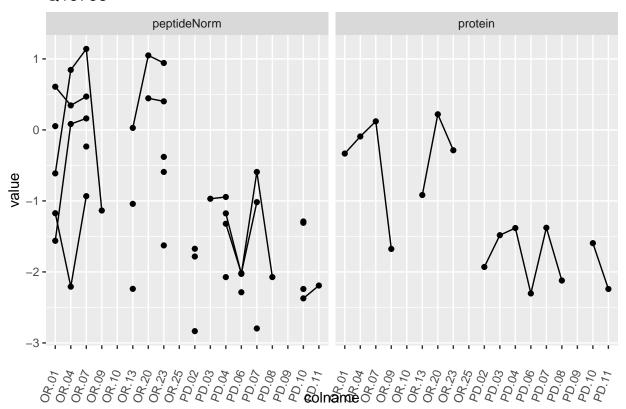


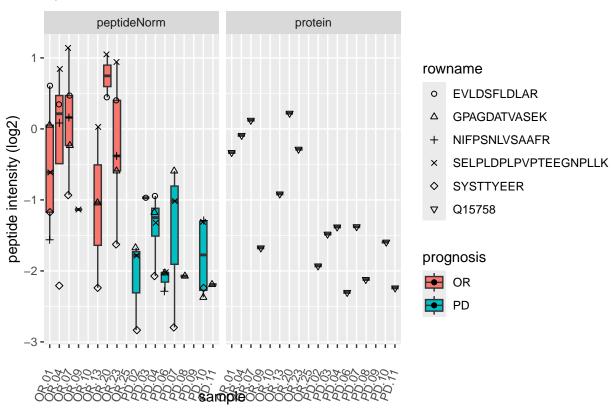
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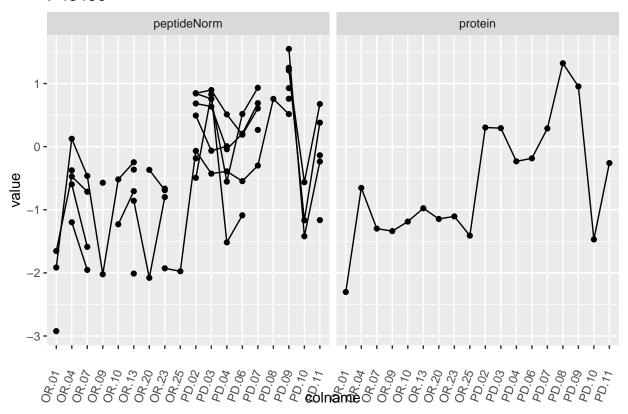
- DASDDLDDLNFFNQK
- DYTYEELLNR Δ
- EKNPDMVAGEK
- EVEPEPTEDKDLEADEEDTR ×
- IESDVQEPTEPEDDLDIMLGNK \Diamond
- **IFDIDEAEEGVK** ∇
- **TGFQAVTGK** ×
- P20042

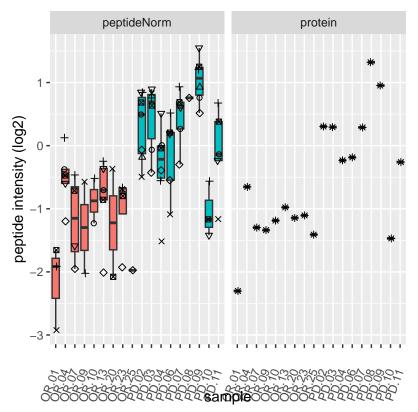












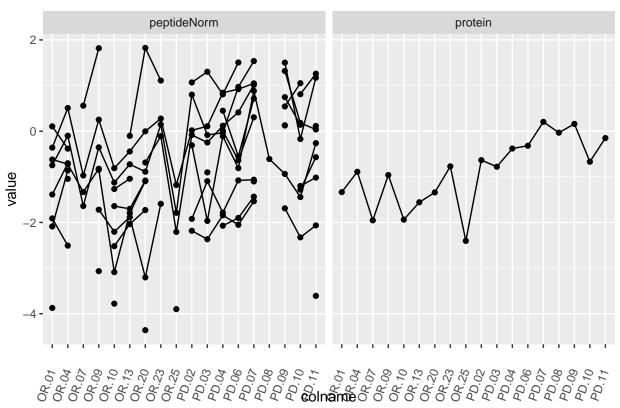
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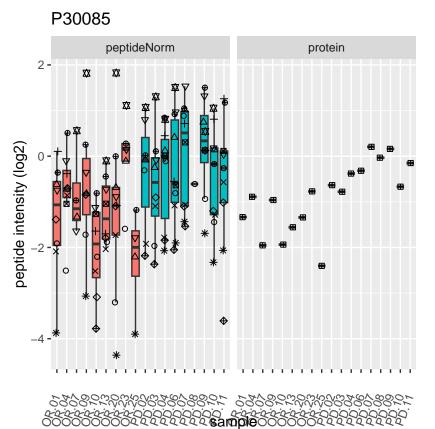
- DVYKEHFQDDVFNEK
- GTDTVAGLALIK Δ
- GVSSQETAGIGASAHLVNFK
- **GWNYILEK** ×
- MNPAAEAEFNILLATDSYK \Diamond
- VIQGDGVDINTLQEIVEGMK
- YLLETSGNLDGLEYK
- P43490

prognosis









prognosis



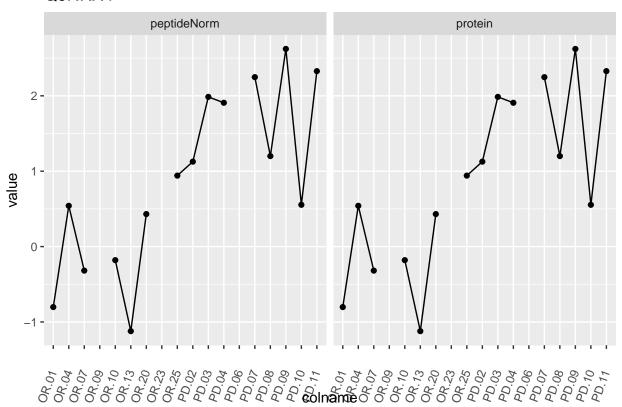


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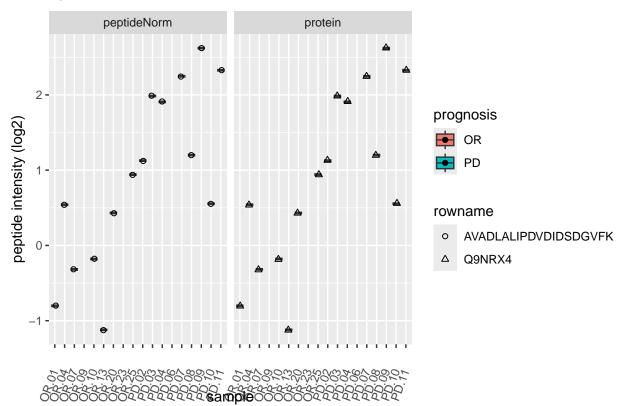
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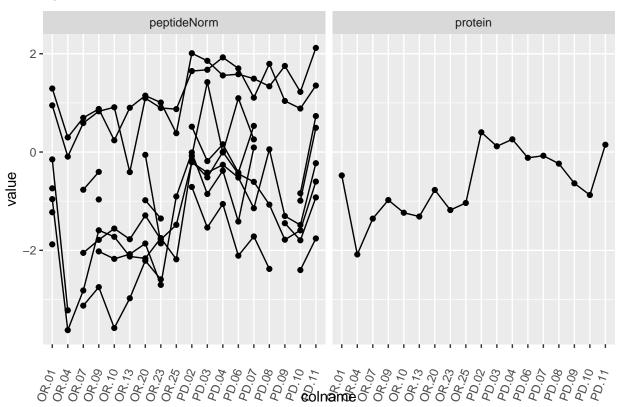
- **EMDQTMAANAQK**
- **FLIDGFPR**
- IQTYLQSTKPIIDLYEEMGK
- **IVPVEITISLLK**
- \Diamond **IVPVEITISLLKR**
- KNPDSQYGELIEK ∇
- NQDNLQGWNK ×
- SDDNRESLEKR
- SVDEVFDEVVQIFDK
- SVDEVFDEVVQIFDKEG
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- P30085

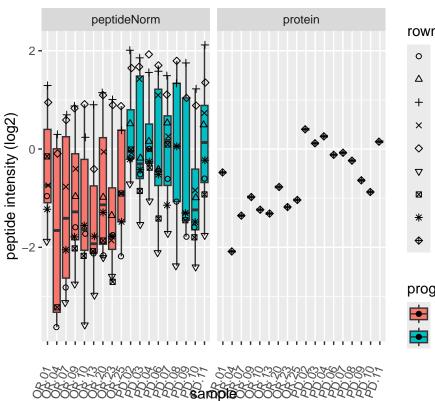
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Q9NRX4







rowname

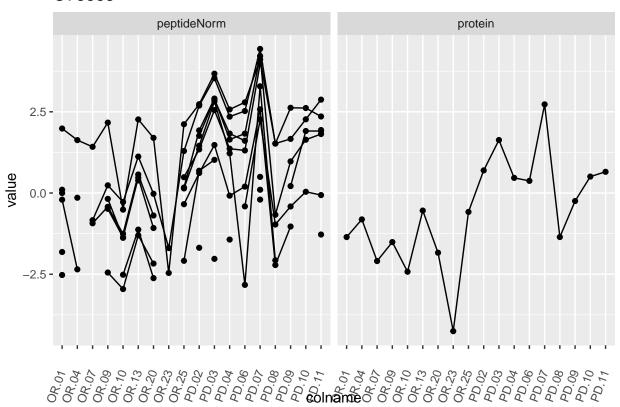
- AMKEYEEEER
- DVQMLQDAISK
- EGEEAGPGDPLLEAVPK
- LGPGGLDPVEVYESLPEELQK
- LQAEAQQLR
- SMVNTKPEK
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- **TGDEKDVSV**
- Q16543

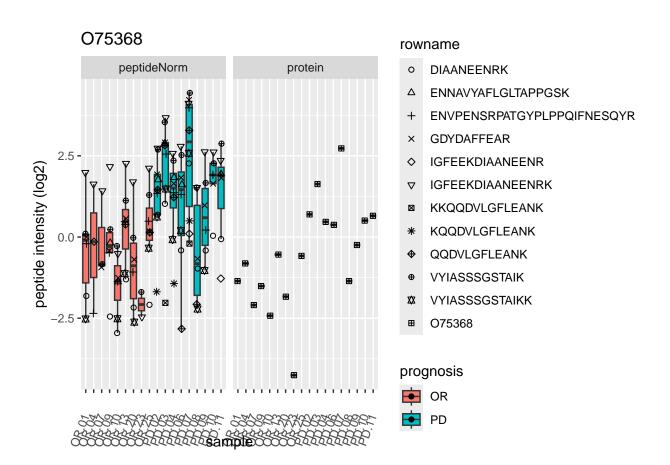
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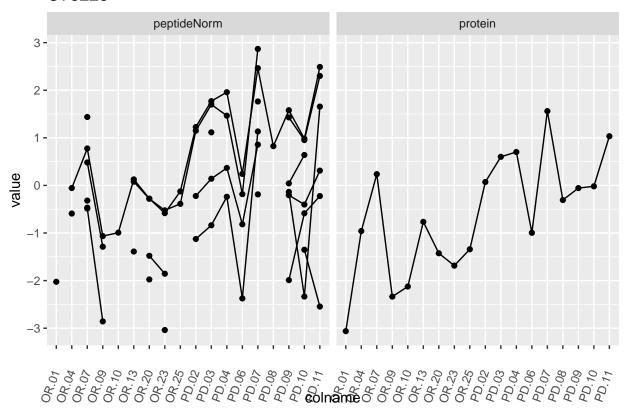


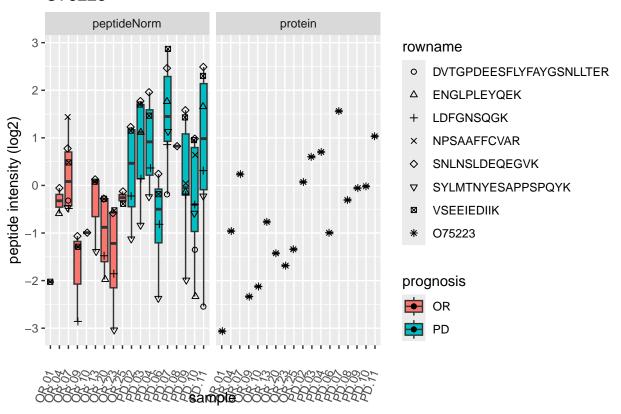
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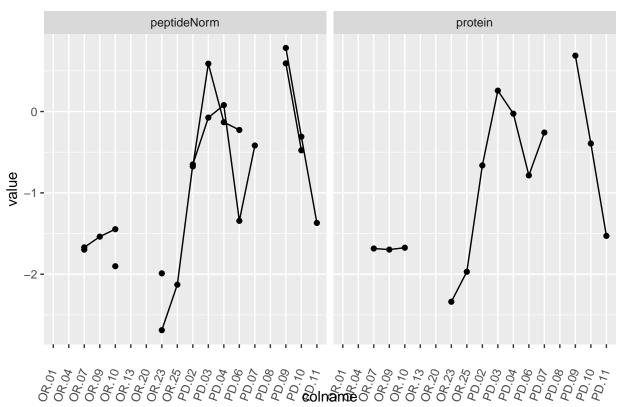


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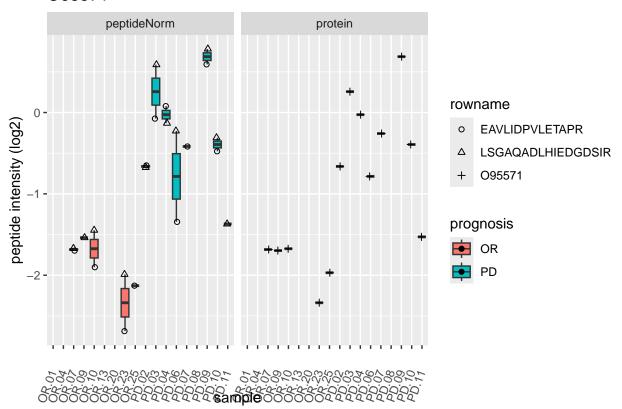




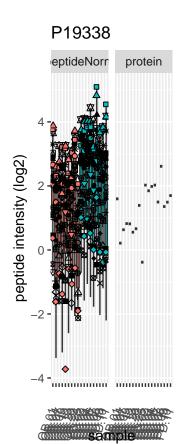
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O95571





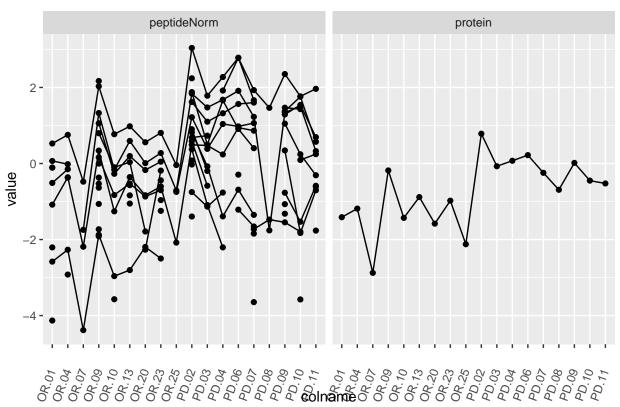


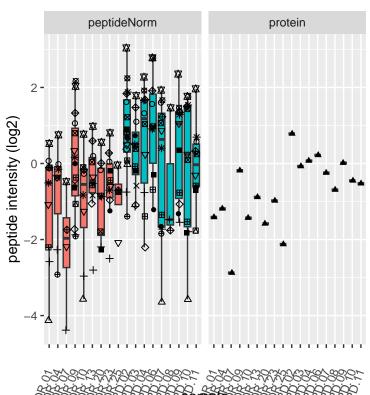


rowname

- ALELTGLK
- △ ALVATPGKK
- + EAMEDGEIDGNK
- × EAMEDGEIDGNKVTLDWAKPK
- ♦ ESFDGSVR
- ▽ EVFEDAAEIR
- FGYVDFESAEDLEK
- * GFGFVDFNSEEDAK
- ♦ GIAYIEFK
- ⊕ GLSEDTTEETLK
- **☎** GLSEDTTEETLKESFDGSVR
- GYAFIEFASFEDAK
- IVTDRETGSSK
- KFGYVDFESAEDLEK
- K\/\/\SPTKK

- LELQGPR
- ▲ NDLAVVDVR
- QKVEGTEPTTAFNLFVGNLNFNK
- SISLYYTGEK
- TEADAEKTFEEK
- TGISDVFAK
- TLVLSNLSYSATEETLQEVFEK
- ♦ VAVATPAKK
- △ VEGTEPTTAFNLFVGNLNFNK
- ∇FGNEIK
 - VTLDWAKPK
 - VTQDELK
 - VTQDELKEVFEDAAEIR
 - **VVVSPTKK**
 - P19338



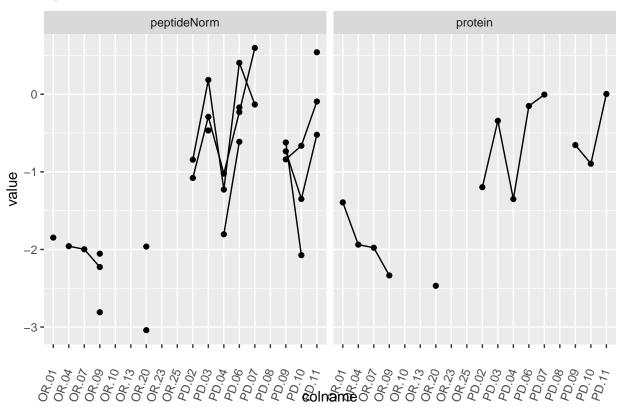


- △ FVKPGAENSR
- + GSVLPNSDKK
- × HSVNNPYSQFQDEYSLDEVMASK
- ♦ HVDLLINK
- □ IGGIFAFK
- ☑ ITGNMGLAMK
- * KLEEEGEQFVK
- ♦ KLEEEGEQFVKK
- LEEEGEQFVK
- □ LQNLQLQPGNAK
- MGFPEAASSFR
- MNPQSAFFQGK
- ☑ VFVVGVGMTK
- WVINPSGGLISK
- YGLSAHPVAPQMFGYAGK
- ▲ P22307

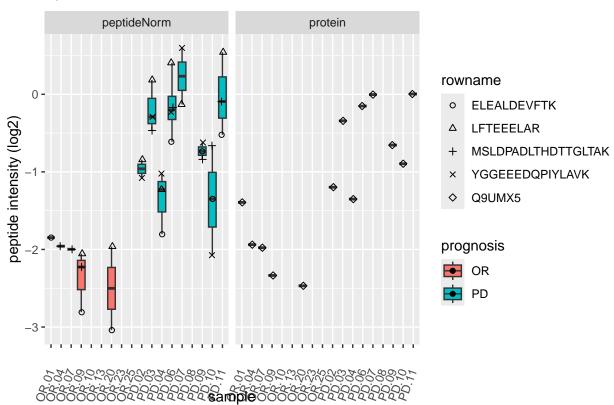
prognosis

OR

Q9UMX5



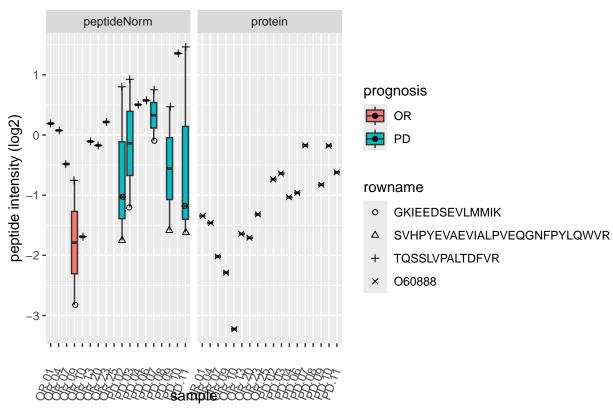
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O60888



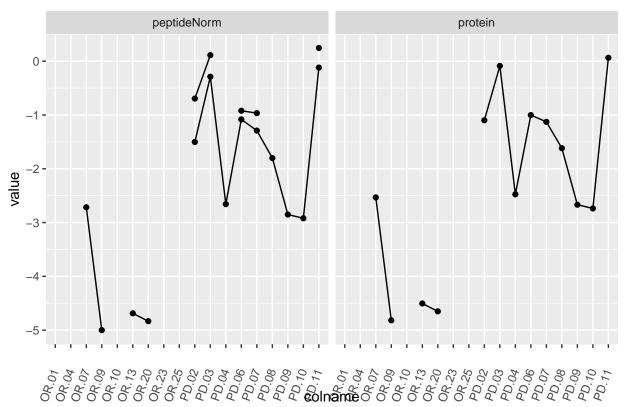
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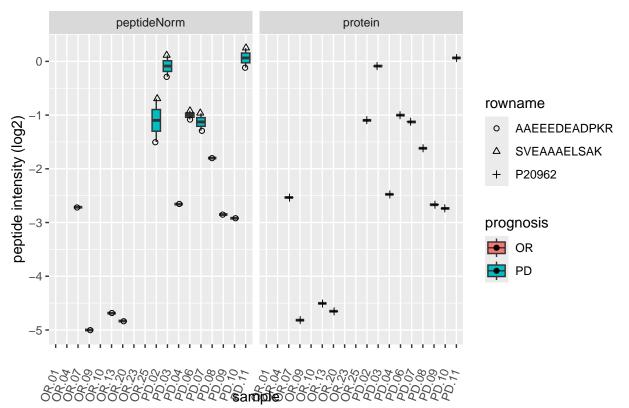


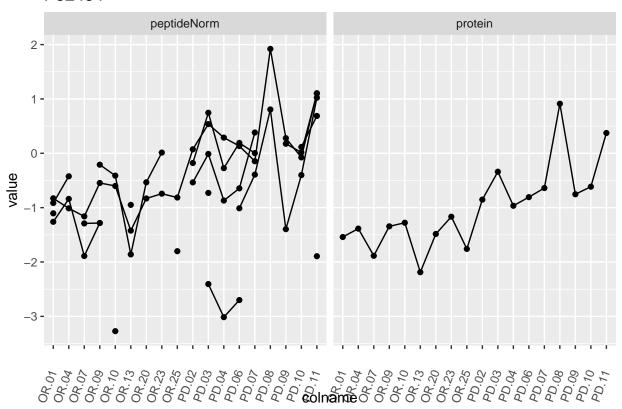
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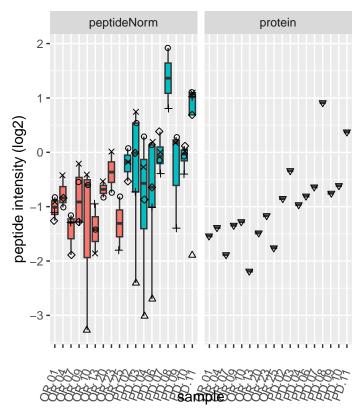


t	%	HLTAQVR	7	LGSPDYGNSALLSLPGYRPTTR	1	QEQHE/
	&	HQVEQLSSSLK	8	LLQAETASNSAR	J	QFCSTC
	,	HREELEQSK	9	LPPKVESLESLYFTPIPAR	К	QFLEVE
١R	(IATTTASAATAAAIGATPR	:	LQAQLNELQAQLSQK	L	QLEALE
)	IHGTEEGQQILK	;	LQNALNEQR	М	QPEWLE
∖AGR		INQLSEENGDLSFK	<	LQQLGEAHQAETEVLR	N	QQEQAI
3EAAGR	+	IQAELAVILK	=	LQQLGEAHQAETEVLRR	0	QQLSSL
≀QEQASQGLR	,	KHPSSPECLVSAQK	>	LSQLEEHLSQLQDNPPQEK	Р	QQNELA
ESECEQLVK	-	KINQLSEENGDLSFK	?	LTAQVASLTSELTTLNATIQQQDQELAGLK	Q	QQNQEI
ГМР		KLDVEEPDSANSSFYSTR	@	LTAQVEQLEVFQR	R	RSQAG\
	/	KNSLISSLEEEVSILNR	Α	LVMAESEK	s	SAPASQ
	0	KQQNQELQEQLR	В	MTMLLLYHSTMSSK	Т	SLEAQV
	1	KVEELQACVETAR	С	NSLISSLEEEVSILNR	U	SLVEQH
STQALVSELLPAK	2	LADDLSTLQEK	D	PSLSLGTITDEEMK	٧	SNRDEL
	3	LALLNEK	E	QAQLAQTLQQQEQASQGLR	W	SNRDEL
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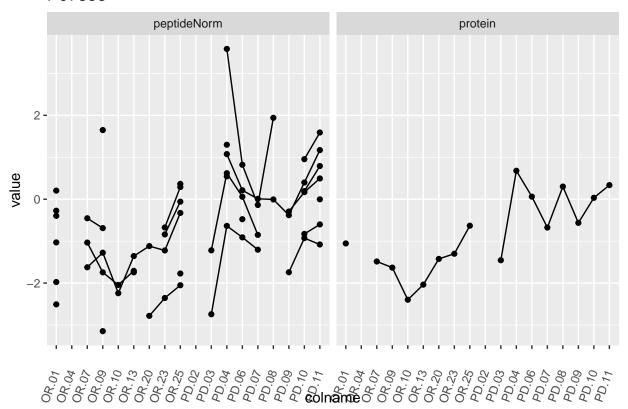
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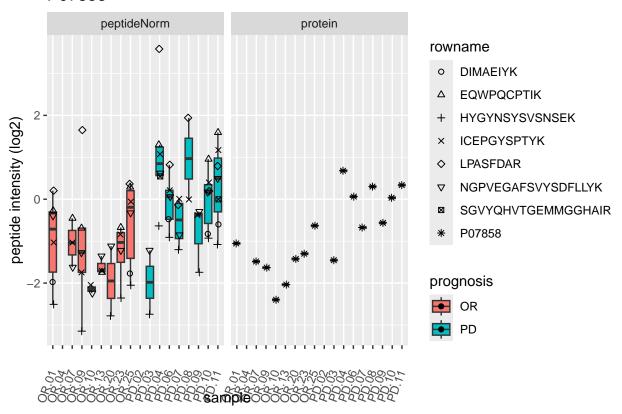
- AGILFEDIFDVK
- △ AGILFEDIFDVKDIDPEGK
- + IEGDETSTEAATR
- × LQGDANNLHGFEVDSR
- ♦ LVIASTLYEDGTLDDGEYNPTDDRPSR
- ▽ P52434

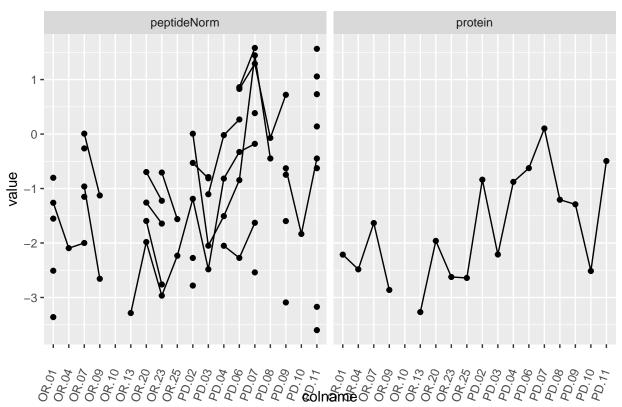
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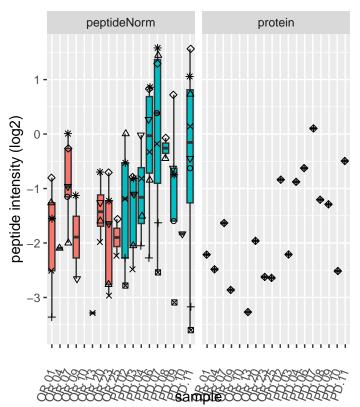












rowname

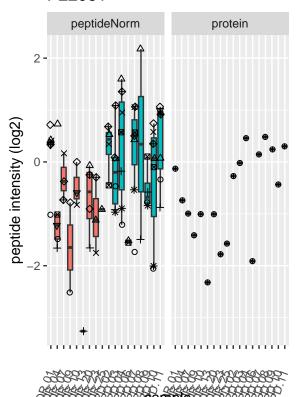
- AAAPAPVSEAVCR
- △ DTMSDQALEALSASLGTR
- + EADPEDGKPVMDK
- × KTEKEESTEVLK
- ♦ LAAAISEVVSQTPASTTQAGAPPR
- ▽ SLTPAVPVESKPDKPSGK
- TEKEESTEVLK
- * TKPQDMISAGGESVAGITAISGKPGDK
- ♦ P20810

prognosis



PD





rowname

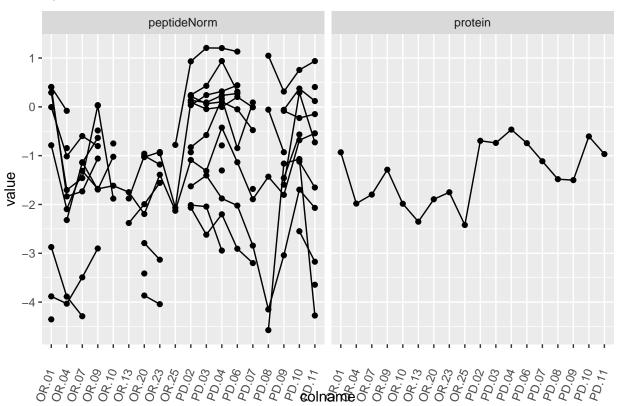
- ALDVGSGSGILTACFAR
- ELVDDSVNNVR
- KDDPTLLSSGR
- LILPVGPAGGNQMLEQYDK
- \Diamond LILPVGPAGGNQMLEQYDKLQDGSIK
- MGYAEEAPYDAIHVGAAAPVVPQALIDQLKPGGR ∇
- SGGASHSELIHNLR
- VFEVMLATDR
- VQLVVGDGR
- P22061

prognosis





Q9Y266



Q9Y266 peptideNorm 1 - (7001) Atlanta in the second of t

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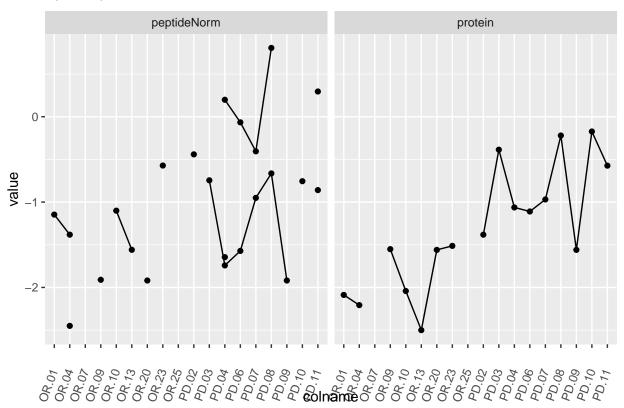
- DAENHEAQLK
- △ ELTDEEAER
- + FMDQHPEMDFSK
- × GQPAIIDGELYNEVK
- ♦ KDAENHEAQLK
- ∇ KINPENSK
- LITQTFSHHNQLAQK
- * LKPNLGNGADLPNYR
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- ⊕ LVSSDPEINTK
- **TDFFIGGEEGMAEK**
- ▼ VEESSWLIEDGK
- Q9Y266

prognosis

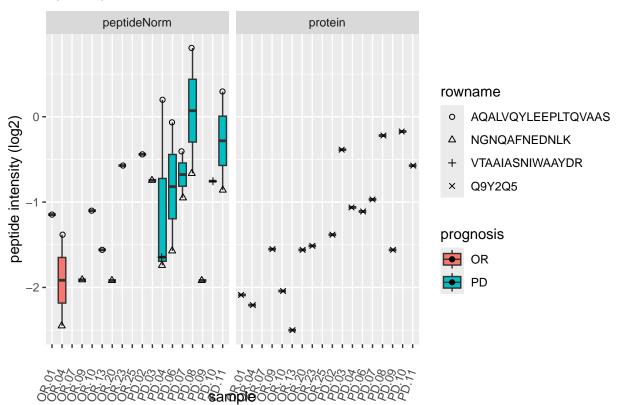


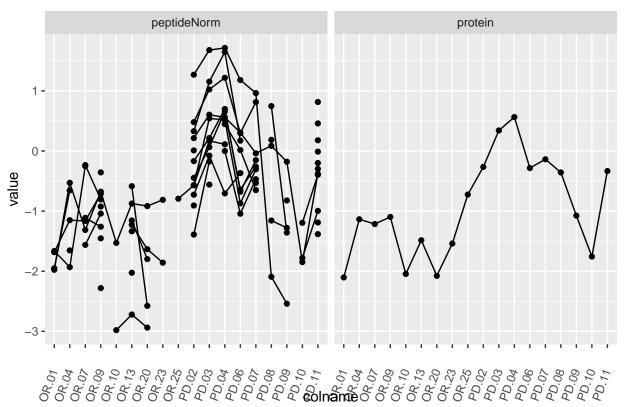
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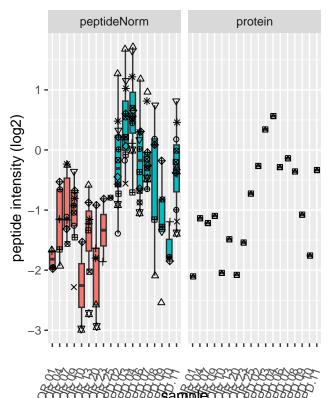
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Q9Y2Q5







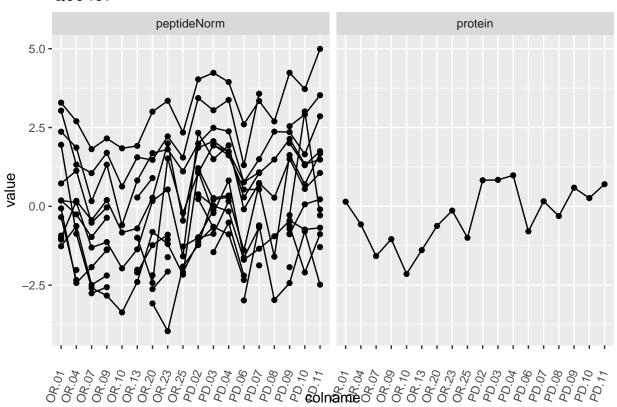
- DGAVNGPSVVGDQTPIEPQTSIER
- Δ EAQLYAAQAHLK
- EIEELKELLPEIR
- **EQVYDAMGEKEEAK**
- **EVSEEQPVVTLEK** \Diamond
- GGAAPEGPNEAEVTSGKPEQEVPDAEEEK
- LSVEESEAAGDGVDTK
- QGTAVEVEAESLDPTVKPVDVGGDEPEEK
- **SGNVAELALK**
- ⊕ **SIEVIENR**
- SLAKPETDKEQDSEMEK
- SLLELAR ⊞
- VDLTLDWLTETSEEAK
- P49321

prognosis

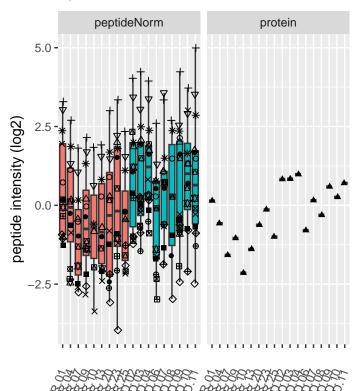




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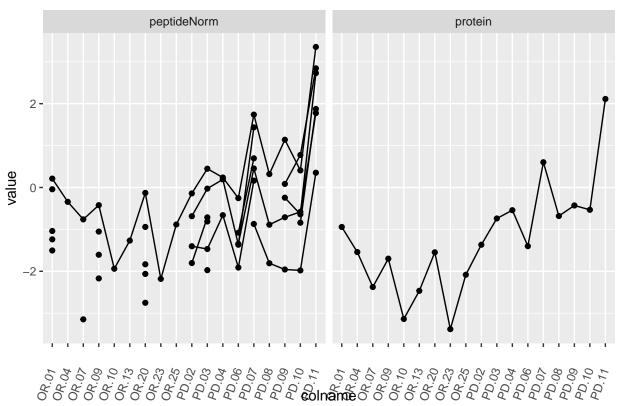
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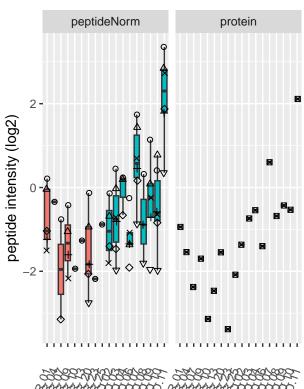


- △ DVVICPDASLEDAKK
- + EGPYDVVVLPGGNLGAQNLSESAAVK
- × EILKEQENR
- ♦ EILKEQENRK
- ▽ GAEEMETVIPVDVMR
- GLIAAICAGPTALLAHEIGFGSK
- * GPGTSFEFALAIVEALNGK
- ◆ GPGTSFEFALAIVEALNGKEVAAQVK
- ⊕ KGLIAAICAGPTALLAHEIGFGSK
- MMNGGHYTYSENRVEK
- VEKDGLILTSR
- VTTHPLAK
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- ▲ Q99497

prognosis







prognosis

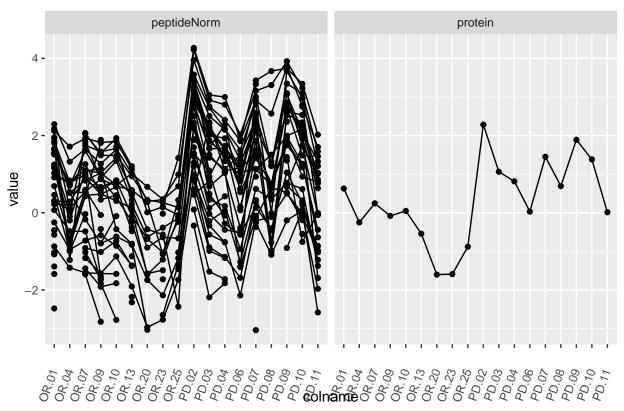


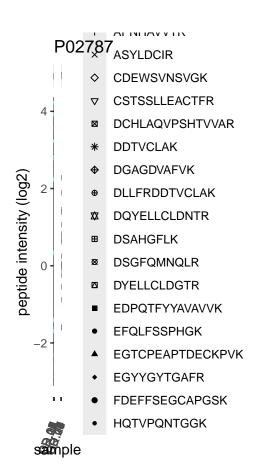
OR



rowname

- AEEYEFLTPVEEAPK
- △ AEQEPTAEQLAQIAAENEEDEHSVNYKPPAQK
- + IDKTDYMVGSYGPR
- × SIQEIQELDKDDESLR
- ♦ SIQEIQELDKDDESLRK
- ∀IQHTYR
- P52565





- → IIVIINGENDAIVIGEDGGI V HAGIN
- △ KASYLDCIR
- ▼ KPVDEYKDCHLAQVPSHTVVAR

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LCMGSGLNLCEPNNK

LKCDEWSVNSVGK

MYLGYEYVTAIR

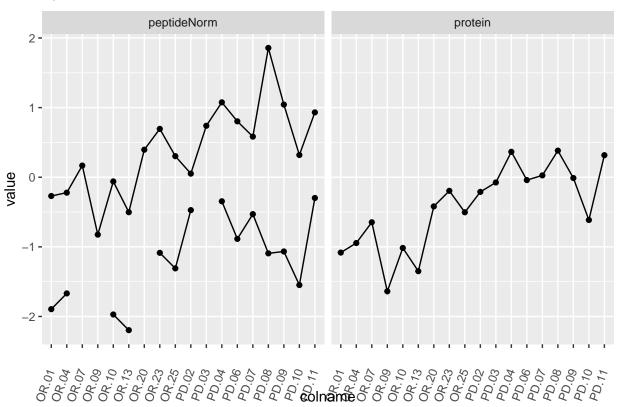
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NPDPWAK

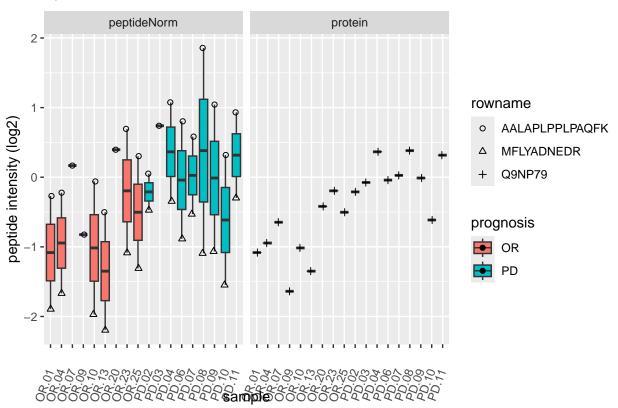
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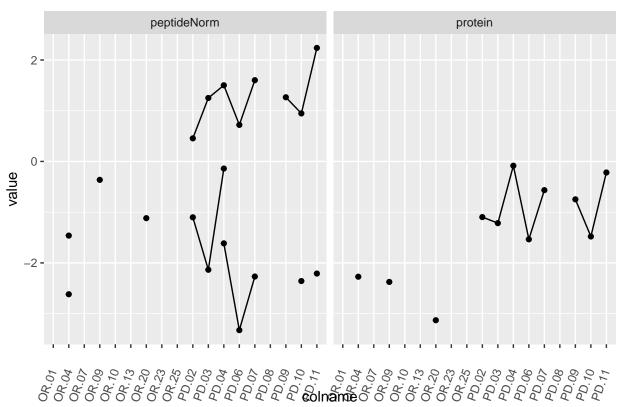
- SASDLTWDNLK
- SKEFQLFSSPHGK
- # SVIPSDGPSVACVK
- **S TAGWNIPMGLLYNK**
- % WCALSHHER
- & WCAVSEHEATK
- YLGEEYVK
- (P02787

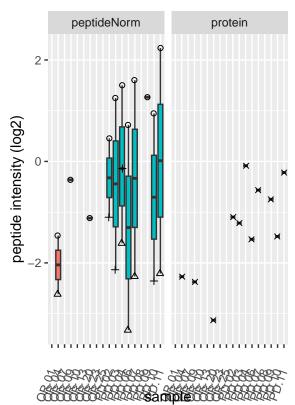
Q9NP79



Q9NP79







rowname

- ATVEPETTPTPNPPTTEEEKTESNQEVANPEHYIK
- **EAVTHIGR**
- IVIGYQSHADTATK
- P06730

prognosis

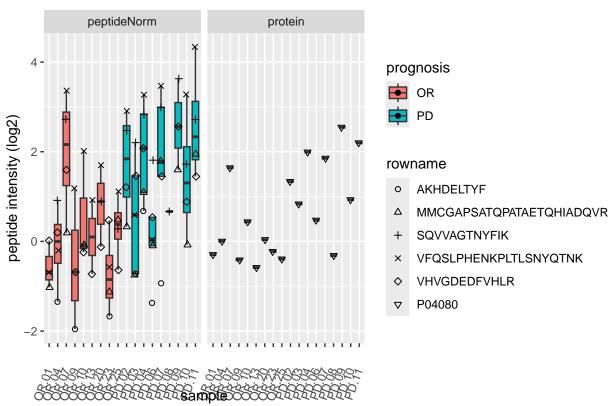


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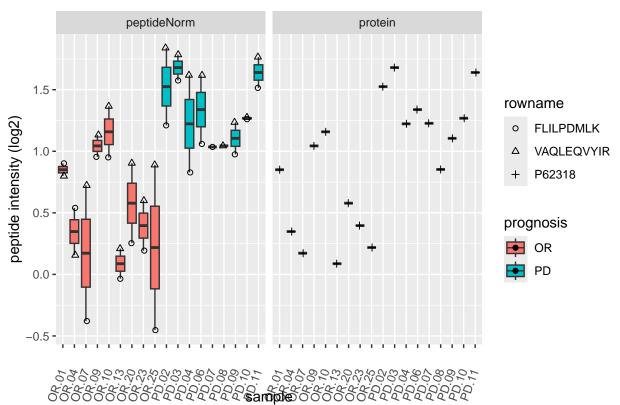


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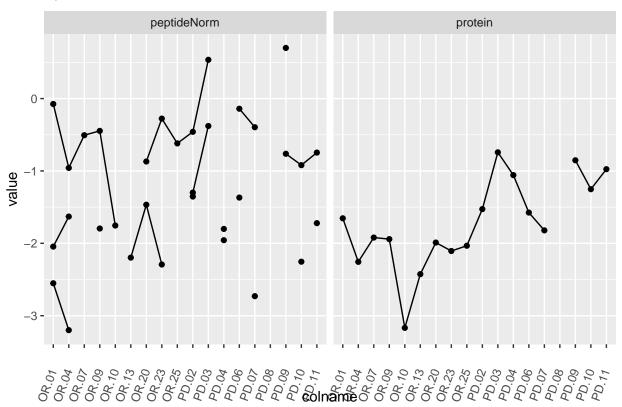




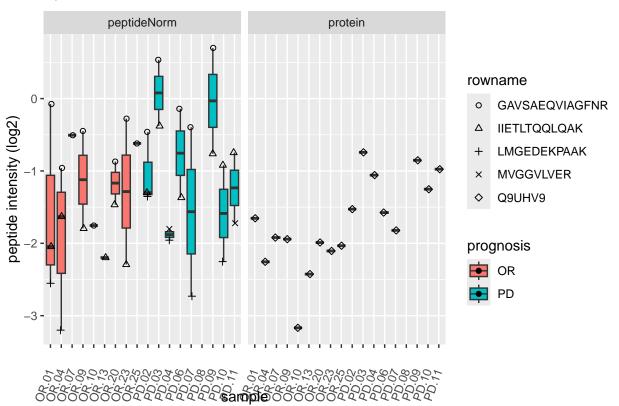


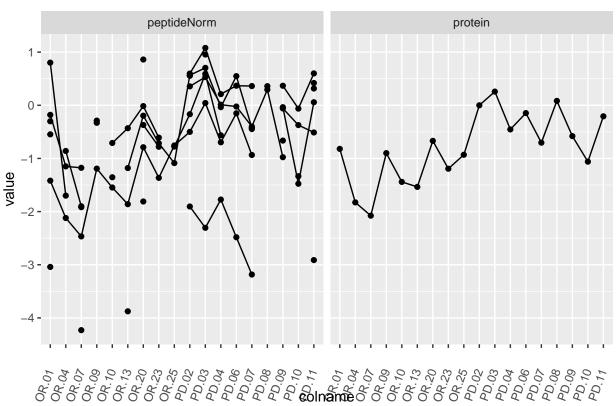


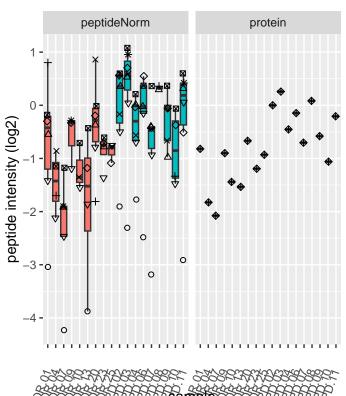
Q9UHV9



Q9UHV9







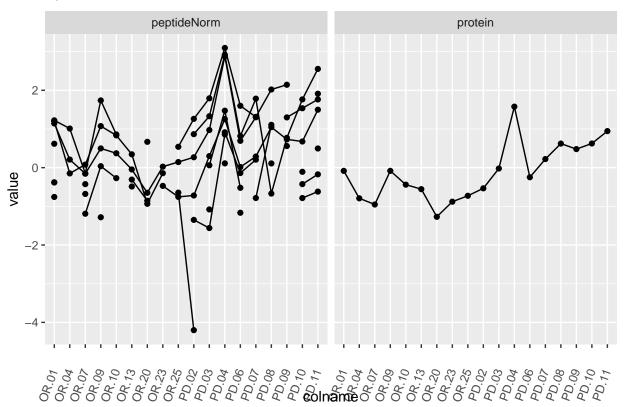
prognosis

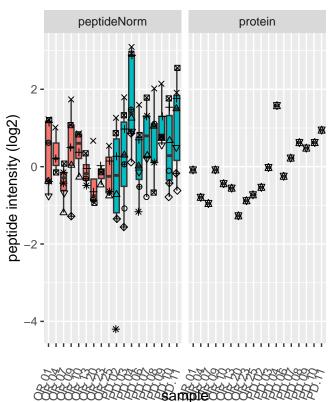


PD

rowname

- **EVLKSEETSK**
- GEIAGPPDTPYEGGR Δ
- **IPETYPFNPPK**
- LWAHVYAGAPVSSPEYTK
- NAVIVALSSK
- SWDVETATELLLSN
- VDLVDENFTELR
- VDLVDENFTELRGEIAGPPDTPYEGGR
- P61086





rowname

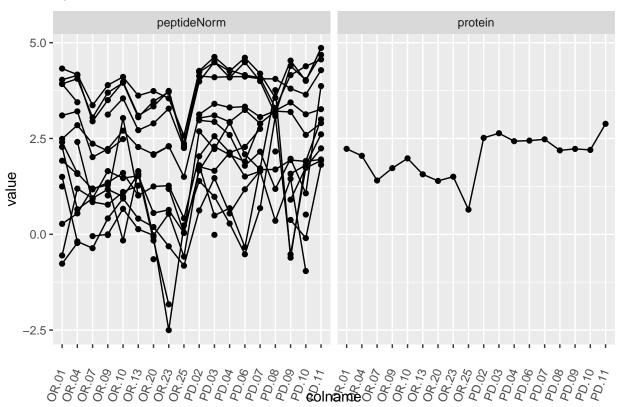
- IPIHNEDITYDELVLMMQR
- △ LLDSLEPPGEPGPSTNIPENDTVDGR
- + LLDSLEPPGEPGPSTNIPENDTVDGREEK
- × LLSNDEVTIK
- ♦ LTLFVNGQPR
- NVMSAFGLTDDQVSGPPSAPAEDR
- * PLESSQVK
- ◆ QSTQVMAASMSAFDPLK
- QSTQVMAASMSAFDPLKNQDEINK
- **☎** Q92734

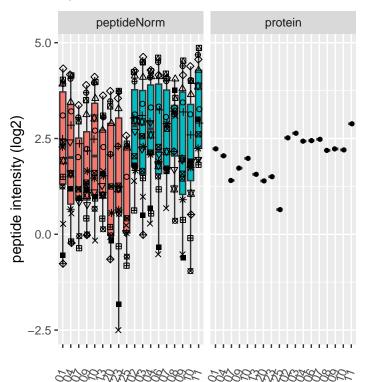
prognosis



OR







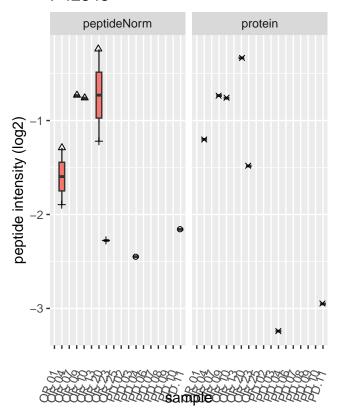
- VDFGIOLIV
- △ ATAVMPDGQFK
- + DISLSDYK
- × GKYVVFFFYPLDFTFVCPTEIIAFSDR
- ♦ HGEVCPAGWKPGSDTIKPDVQK
- ∇ IGHPAPNFK
- KQGGLGPMNIPLVSDPK
- * KQGGLGPMNIPLVSDPKR
- ◆ LNCQVIGASVDSHFCHLAWVNTPK
- UVQAFQFTDK
- ☆ QGGLGPMNIPLVSDPK
- QGGLGPMNIPLVSDPKR
- SKEYFSK
- TIAQDYGVLK
- YVVFFFYPLDFTFVCPTEIIAFSDR
- Q06830

prognosis



OR



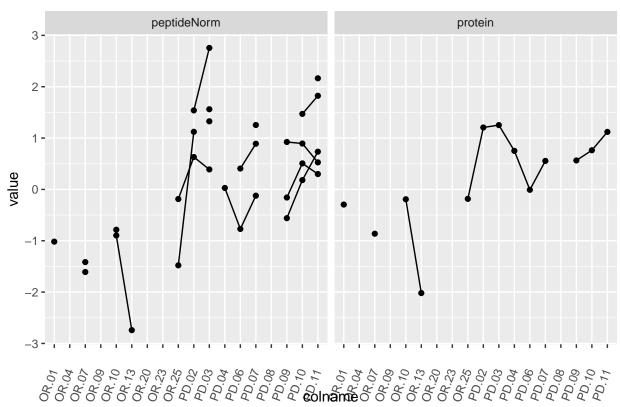


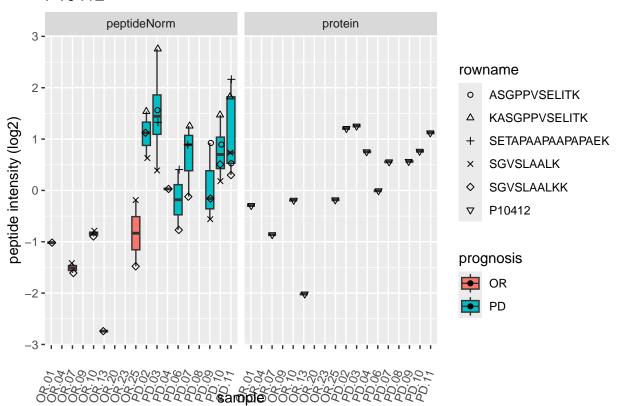
prognosis



rowname

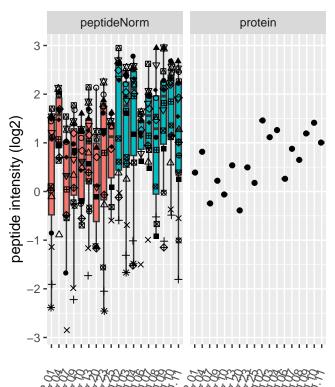
- LTESLDFTDYASR
- △ MLGTGPAAATTAATTSSNVSVLQQFASGLK
- + VLGLLGALDPYK
- × P42345





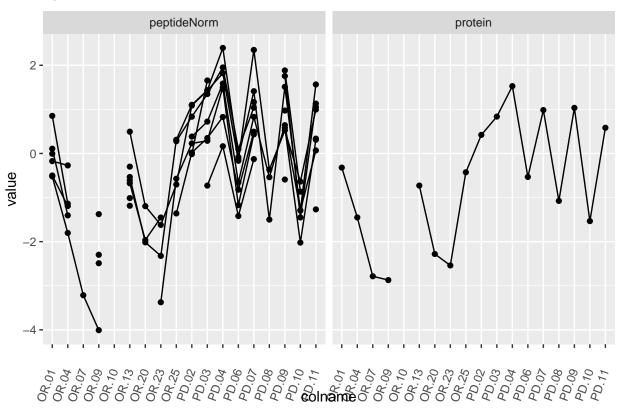
P14314

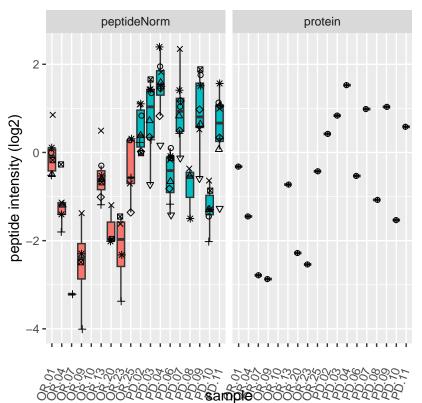




- + DMEESIR
- × ERESLQQMAEVTR
- ♦ ESLQQMAEVTR
- ▼ ETMVTSTTEPSR
- ILIEDWK
- * KLIELQAGK
- ♦ LGGSPTSLGTWGSWIGPDHDK
- LGGSPTSLGTWGSWIGPDHDKFSAMK
- NKFEEAER
- SEALPTDLPAPSAPDLTEPK
- SLEDQVEMLR
- SLKDMEESIR
- TVKEEAEKPER
- ▲ VNDGVCDCCDGTDEYNSGVICENTCK
- YEQGTGCWQGPNR
- P14314

prognosis





rowname

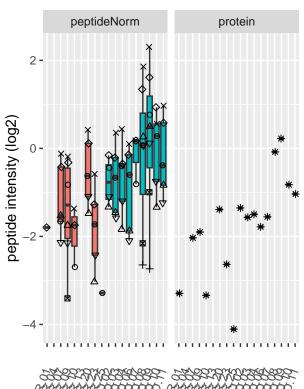
- AADLNGDLTATR
- △ EQFNEFR
- + HLVYESDKNKDEK
- × HWILPQDYDHAQAEAR
- ♦ IDNDGDGFVTTEELK
- □ ISWEEYK
- IVDRIDNDGDGFVTTEELK
- * TFDQLTPDESKER
- ♦ YIFDNVAK
- Q15293

prognosis



PD PD





rowname

- AAEEPSKVEEK
- △ AEDGATPSPSNETPK
- + EAGEGGEAEAPAAEGGK
- × EAPAEGEAAEPGSPTAAEGEAASAASSTSSPK
- ▼ GEPAAAAAPEAGASPVEK
- VNGDASPAAAESGAK
- * P29966

prognosis

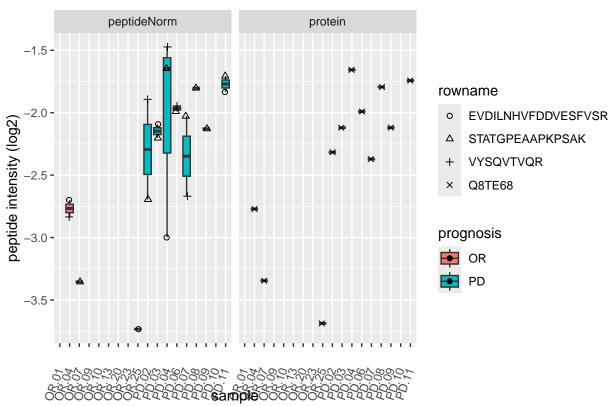


PD

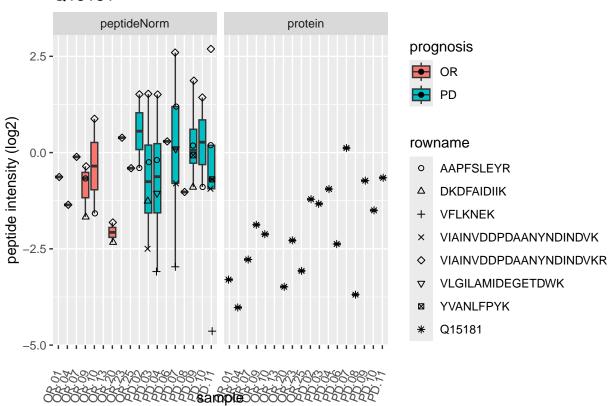
Q8TE68



Q8TE68



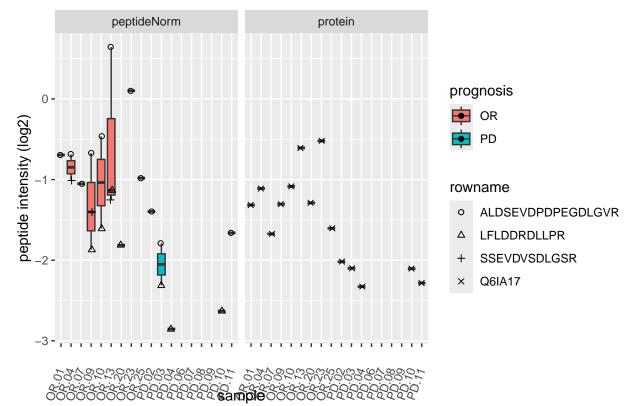


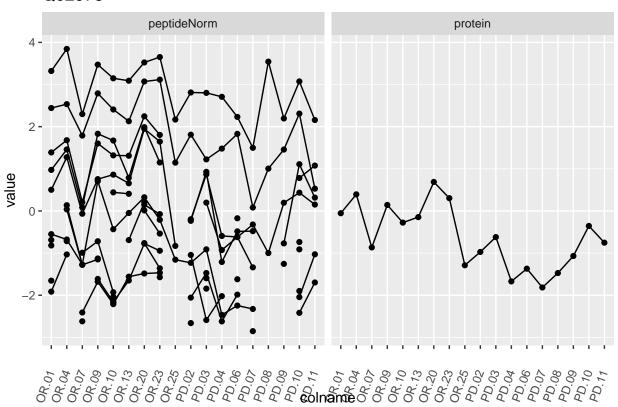


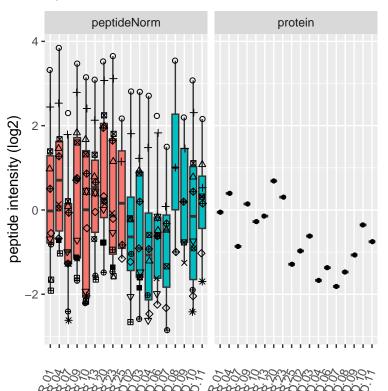
Q6IA17



Q6IA17





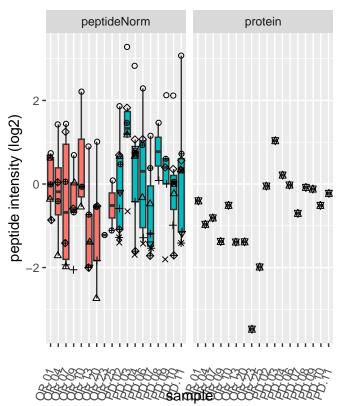




rowname

- AATASAGAGGIDGKPR
- △ AVIGMTAGATGAFVGTPAEVALIR
- + AVVVNAAQLASYSQSK
- × EEGVLTLWR
- ♦ FLFGGLAGMGATVFVQPLDLVK
- ∇ GIYTGLSAGLLR
- LGIYTVLFER
- * LGPHTVLTFIFLEQMNK
- **♦ LTGADGTPPGFLLK**
- ⊕ MIDGKPEYK
- NGLDVLFK
- NVFNALIR
- RGYKNVFNALIR
- TSFHALTSILK





rowname

- AEDNADTLALVFEAPNQEK
- △ ATPLSSTVTLSMSADVPLVVEYK
- + CAGNEDIITLR
- × DLSHIGDAVVISCAK
- ♦ FSASGELGNGNIK
- □ IADMGHLK
- LSQTSNVDKEEEAVTIEMNEPVQLTFALR
- * MPSGEFAR
- ♦ NLAMGVNLTSMSK
- ⊕ YLNFFTK

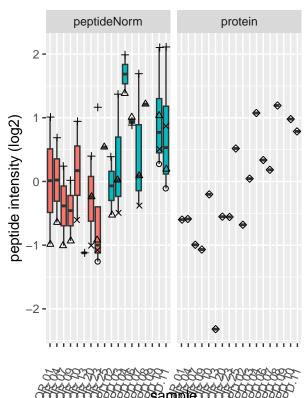
prognosis



OR







rowname

- FAAEEFKVPAATSAIITNDGIGINPAQTAGNVFLK
- △ ITLTSDPR
- + VLSVPESTPFTAVLK
- × VPAATSAIITNDGIGINPAQTAGNVFLK
- ♦ P61960

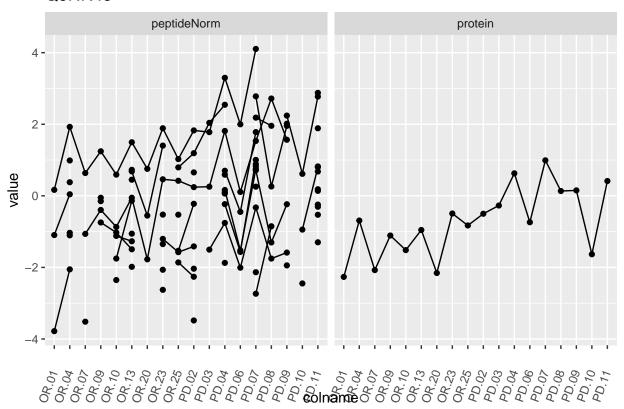
prognosis



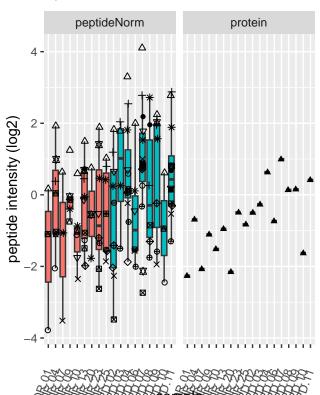
OR



Q9NR45



Q9NR45

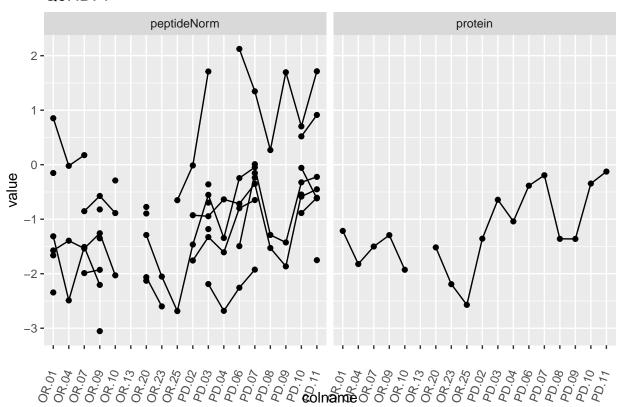


- △ GSDHSASLEPGELAELVR
- + GYPPEDIFNLVGK
- × GYPPEDIFNLVGKK
- ♦ HLEFSHDQYR
- □ IPEGTILTMDMLTVK
- KALERPYTSK
- * LFPDIPIGYSGHETGIAISVAAVALGAK
- ♦ PLELELCPGR
- ⊕ QLLPCEMACNEK
- □ VGSGDTNNFPYLEK
 □ VGSGDTNNFPYLEK
- VISEYQK
- VKIPEGTILTMDMLTVK
- VLVTVEEDDTIMEELVDNHGK
- VLVTVEEDDTIMEELVDNHGKK
- YAEEVGIFFTASGMDEMAVEFLHELNVPFFK
- ▲ Q9NR45

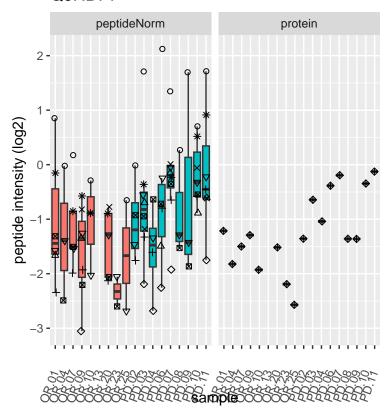
prognosis



Q9HB71



Q9HB71



prognosis



OR



PD

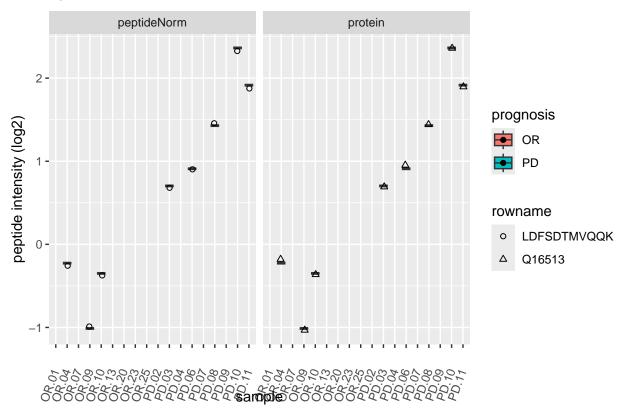
rowname

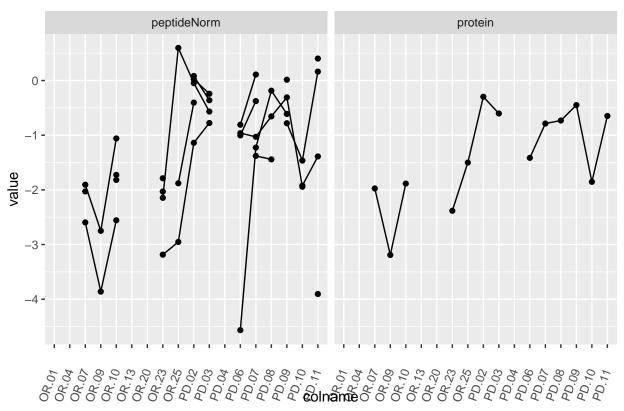
- ASEELQKDLEEVK
- △ EKPSYDTETDPSEGLMNVLK
- + ISNYGWDQSDK
- × KAELLDNEKPAAVVAPITTGYTVK
- ♦ KIYEDGDDDMKR
- SKIETEIK
- * SYSMIVNNLLKPISVEGSSK
- ♦ Q9HB71

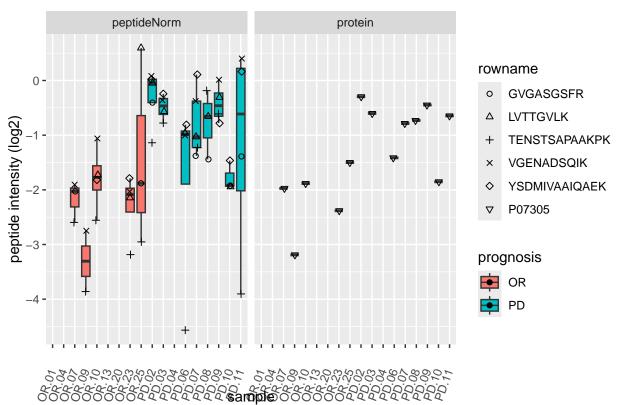
Q16513

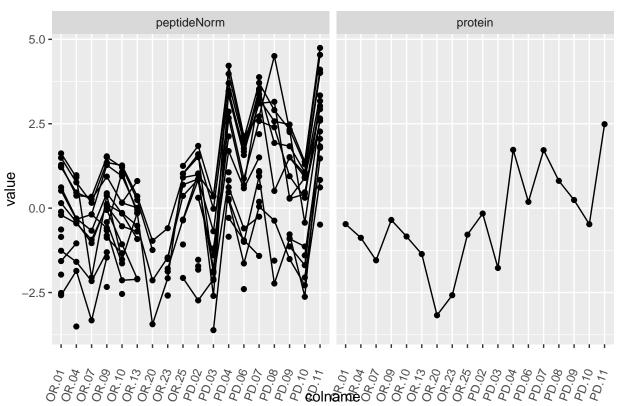


Q16513

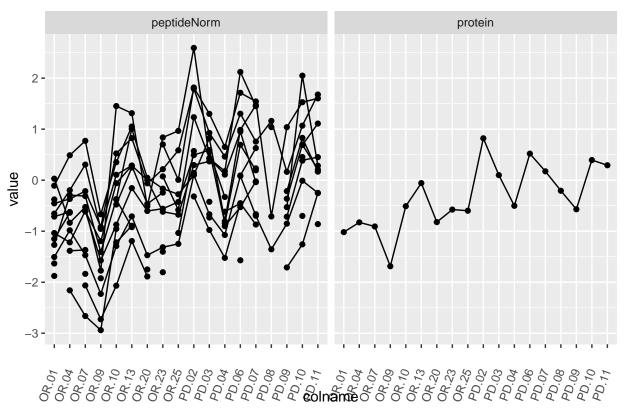


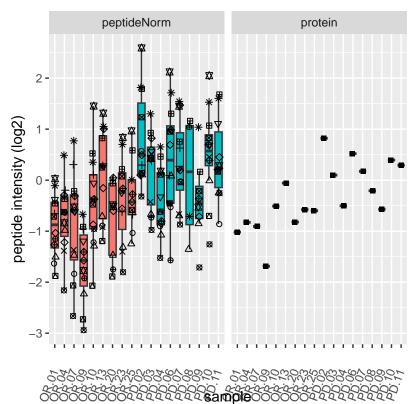












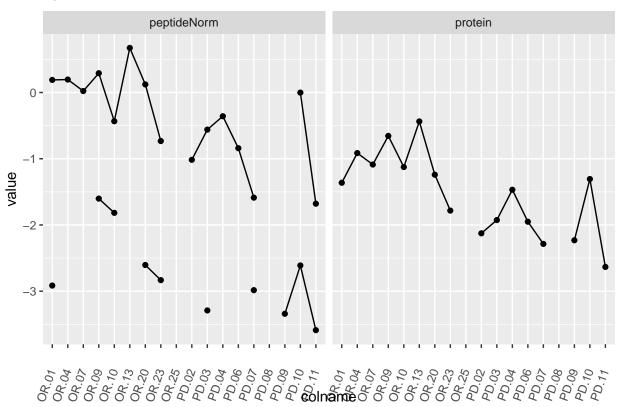
- **AMMYSGELK**
- **EDLVVAPAGITLK** Δ
- FGVPVIADGGIQNVGHIAK +
- GKLPIVNEDDELVAIIAR ×
- KYEQGFITDPVVLSPK **\quad**
- LPIVNEDDELVAIIAR ∇
- **LVGIISSR** ×
- NLIDAGVDALR
- REDLVVAPAGITLK
- RFGVPVIADGGIQNVGHIAK
- 苁 TSSAQVEGGVHSLHSYEK
- VAQGVSGAVQDK ⊞
- YEQGFITDPVVLSPK
- YFSEADKIK
- P12268

prognosis

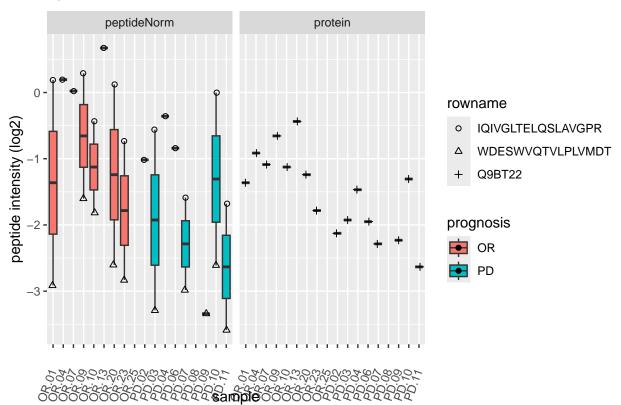




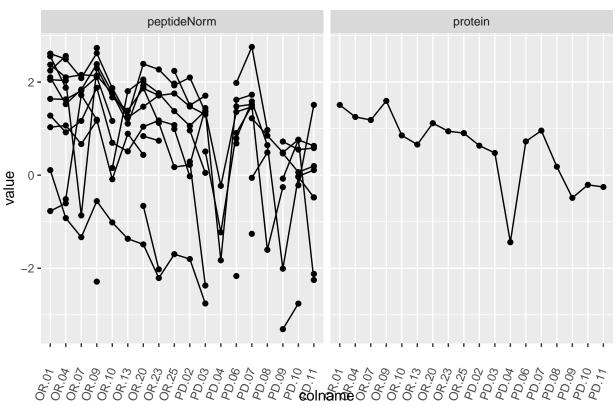
Q9BT22



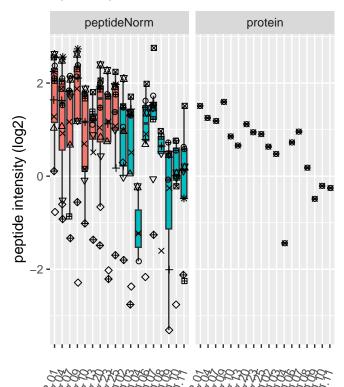
Q9BT22



Q9UHQ9



Q9UHQ9



rowname

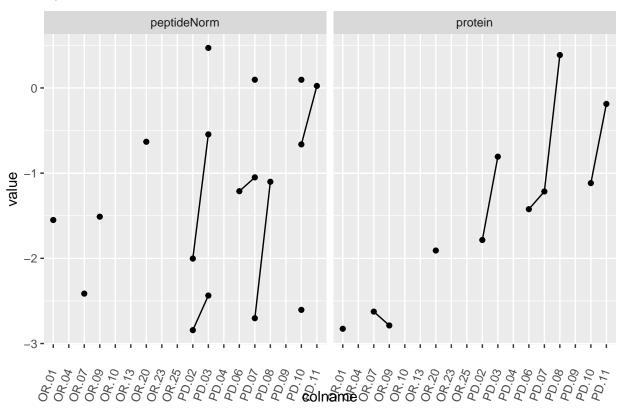
- DIILREDLEELQAR
- **EDLEELQAR**
- FALPTAHHTLGLPVGK
- **GFVTADMIR** ×
- **GHFNIQPNKK** \Diamond
- GIQTSPVLLASLGVGLVTLLGLAVGSYLVR ∇
- **GPSGLLTYTGK** ×
- IDGSLVIRPYTPVTSDEDQGYVDLVIK
- LGMIAGGTGITPMLQLIR
- MSQYLDSLK
- RPQVTLLDPNEK 苁
- VGDVVEFR
- Q9UHQ9

prognosis

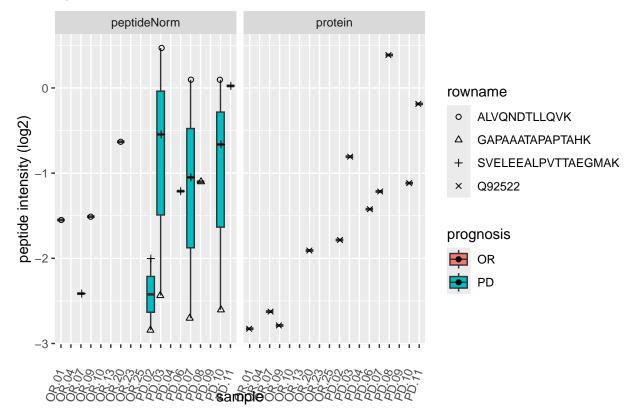




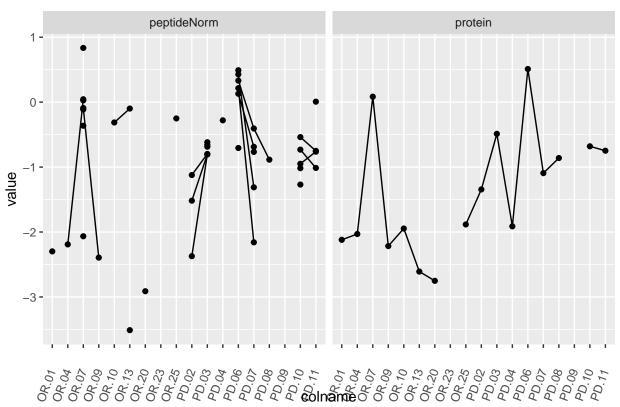
Q92522



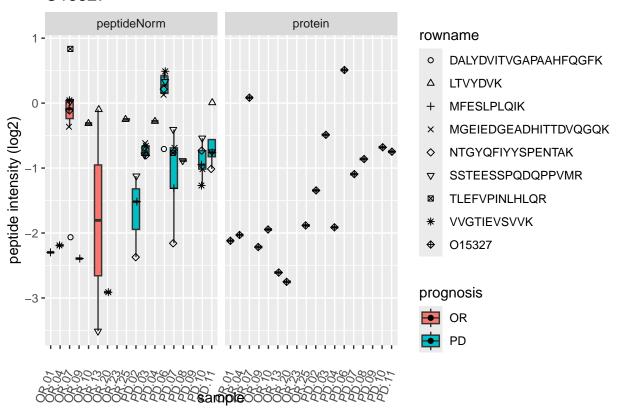
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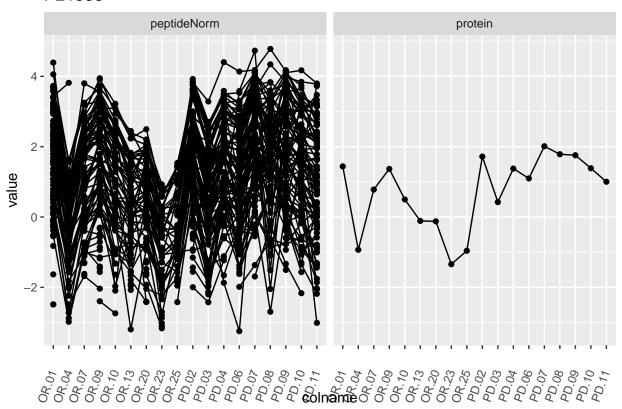


O15327



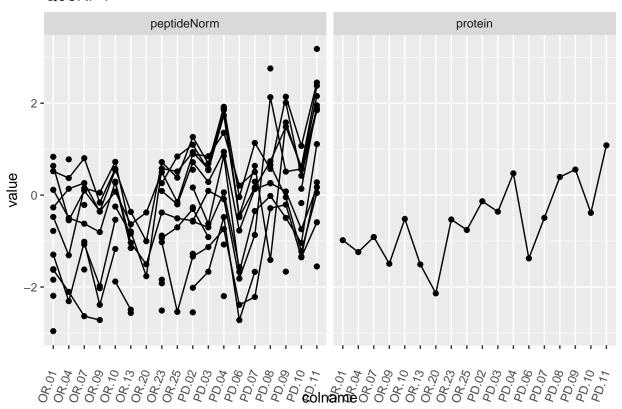
O15327



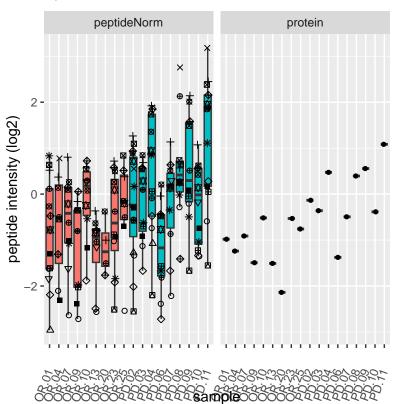


)	GAGSYTIMVLFADQATPTSPIR	<	LVSNHSLHETSSVFVDSLTK
/K	*	GAGTGGLGLAVEGPSEAK	=	LYSVSYLLK
TYGGHQVPGSPFK	+	GKLDVQFSGLTK	>	MDCQECPEGYR
	,	GLVEPVDVVDNADGTQTVNYVPSR	?	NDNDTFTVK
IVTITWGGQNIGR	-	GQHVPGSPFQFTVGPLGEGGAHK	@	NGHVGISFVPK
		GTVEPQLEAR	Α	NGQHVASSPIPVVISQSEIGDASI
	/	HTAMVSWGGVSIPNSPFR	В	PGAPLRPK
	0	IANLQTDLSDGLR	С	RAEFTVETR
IVDPNVDEHSVMTYLSQFPK	1	IECDDKGDGSCDVR	D	RAPSVANVGSHCDLSLK
	2	IPEISIQDMTAQVTSPSGK	Е	RLTVSSLQESGLK
PFPLEAVAPTKPSK	3	IVGPSGAAVPCK	F	SADFVVEAIGDDVGTLGFSVEGF
	4	KGEITGEVR	G	SAGQGEVLVYVEDPAGHQEEAK
	5	KTHIQDNHDGTYTVAYVPDVTGR	Н	SPFEVYVDK
	6	LDVQFSGLTK	1	SPFSVAVSPSLDLSK
	7	LIALLEVLSQKK	J	SPYTVTVGQACNPSACR
QPSVQPPLR	8	LLGWIQNKLPQLPITNFSR	К	TFSVWYVPEVTGTHK
DAR	9	LQVEPAVDTSGVQCYGPGIEGQGVFR	L	TGVAVNKPAEFTVDAK

Q96KP4



Q96KP4





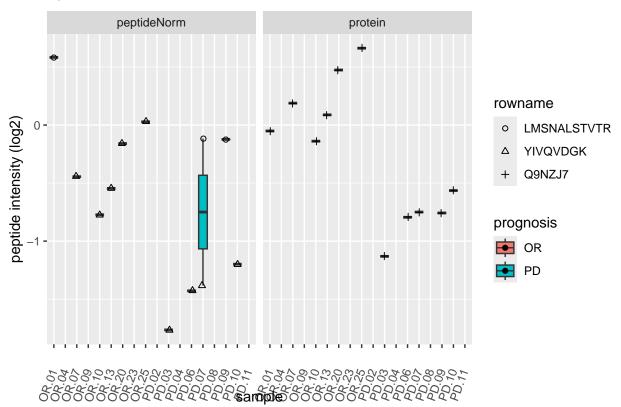
rowname

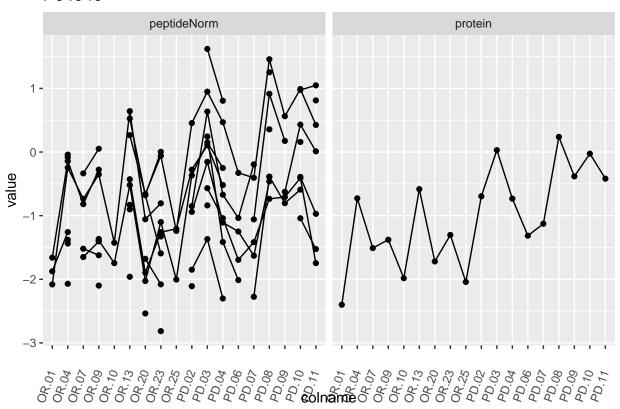
- AALTTLFK
- △ DVGAQILLHSHK
- + EGGSIPVTLTFQEATGK
- × GNILIPGINEAVAAVTEEEHK
- ♦ LPDGSEIPLPPILLGR
- □ LVPNMTPEVVGEQVTSYLTK
- LYDDIDFDIEEFAK
- * MMEVAAADVK
- ♦ NVMLLPVGSADDGAHSQNEK
- QKLPDGSEIPLPPILLGR
- □ QLGGSVELVDIGK
- **TGQEIPVNVR**
- ▼ TVFGVEPDLTR
- WVAIQSVSAWPEK
- YNYIEGTK

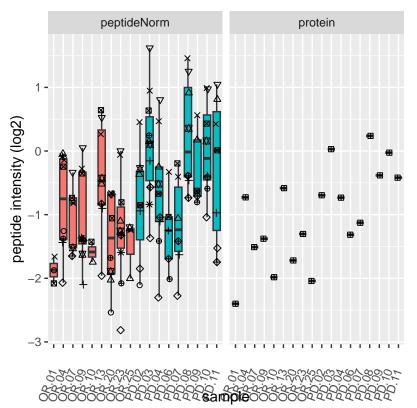
Q9NZJ7



Q9NZJ7







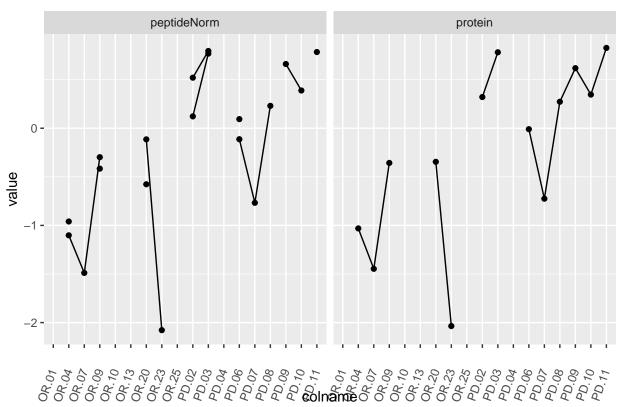
prognosis

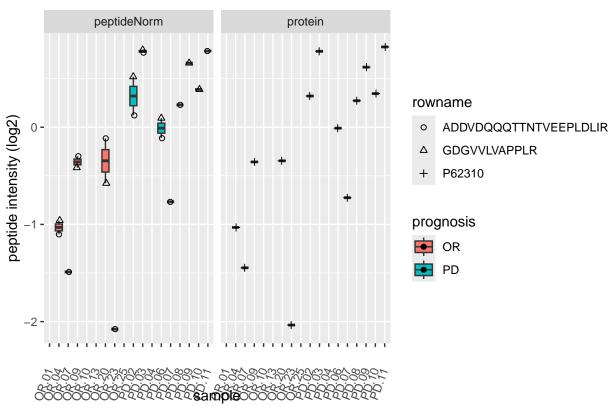




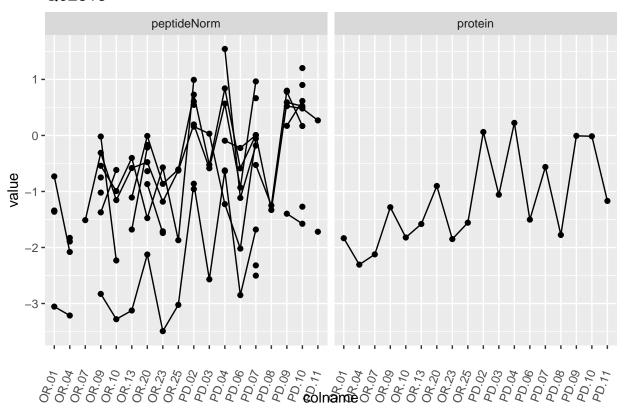
rowname

- ADSRDPASDQMQHWKEQR
- △ ADVLTTGAGNPVGDK
- + AFYVNVLNEEQR
- × FNTANDDNVTQVR
- ♦ FSTVAGESGSADTVR
- ▼ FSTVAGESGSADTVRDPR
- GAGAFGYFEVTHDITK
- * LGPNYLHIPVNCPYR
- ♦ LNVITVGPR
- ⊕ LSQEDPDYGIR
- **■** P04040

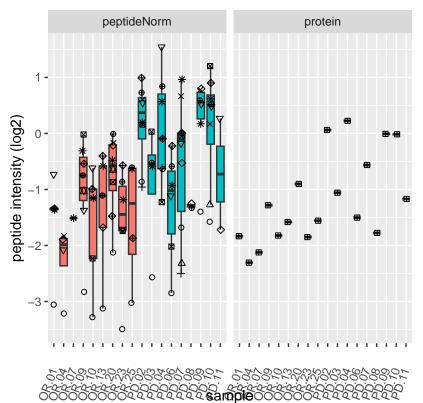




Q02818



Q02818



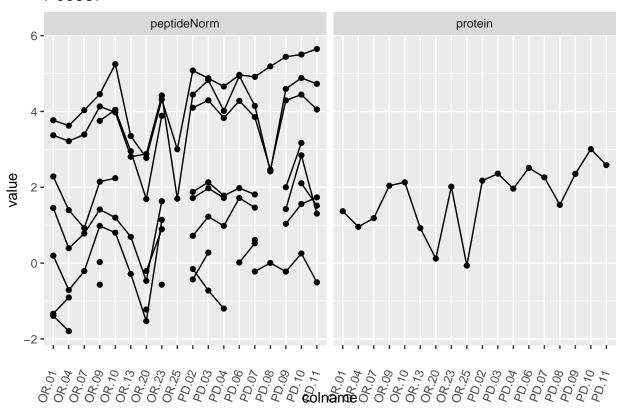
rowname

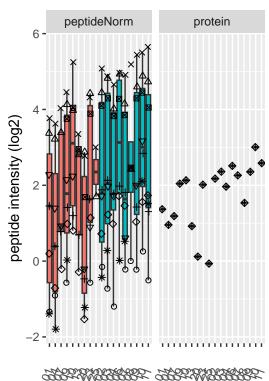
- APAAHPEGQLK
- △ DLAQYDAAHHEEFKR
- + ELQQAVLHMEQR
- × LPEVEVPQHL
- ♦ LQAANAEDIK
- LVTLEEFLASTQR
- * MDAEQDPNVQVDHLNLLK
- ♦ QFEHLDPQNQHTFEAR
- ♥ VNVPGSQAQLK
- ☆ YLQEVIDVLETDGHFR
- **■** Q02818

prognosis



🙀 PD





rowname

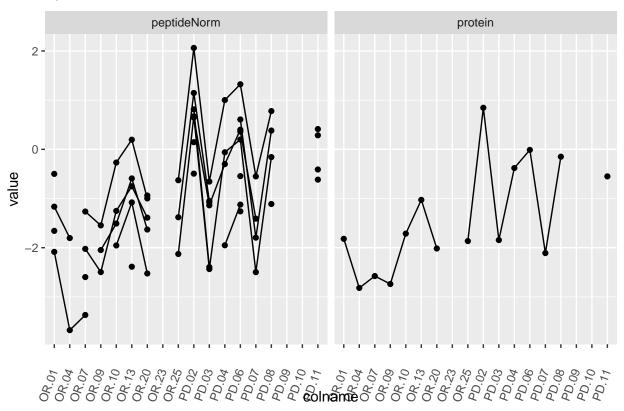
- ILDSVGIEADDDR
- △ ILDSVGIEADDDRLNK
- + KILDSVGIEADDDRLNK
- × LASVPAGGAVAVSAAPGSAAPAAGSAPAAAEEK
- ♦ LASVPAGGAVAVSAAPGSAAPAAGSAPAAAEEKKDEK
- NIEDVIAQGIGK
- * YVASYLLAALGGNSSPSAK
- ♦ P05387

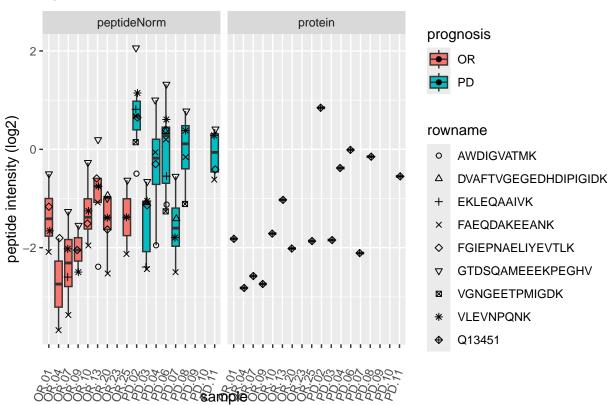
prognosis

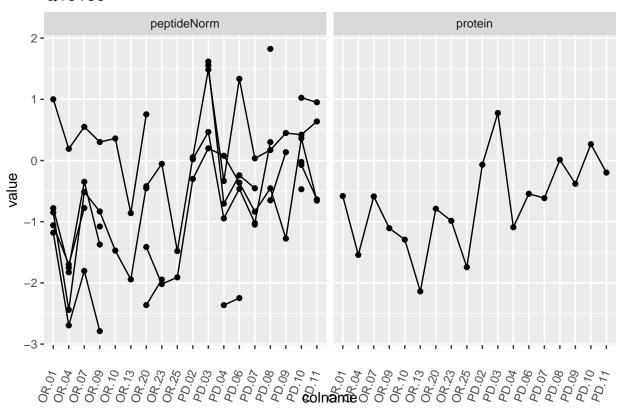


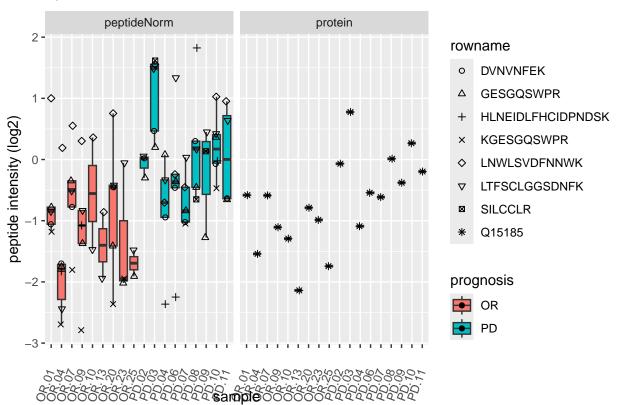
OR

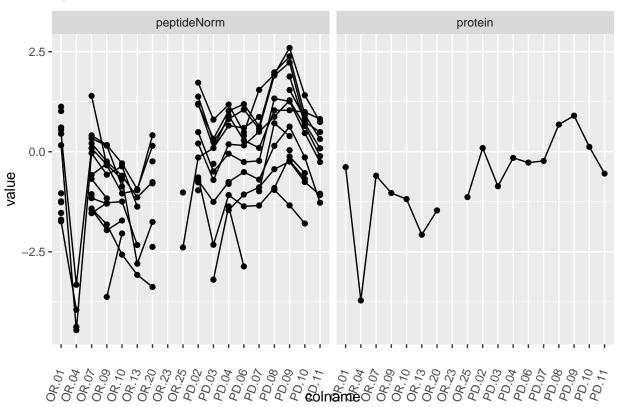


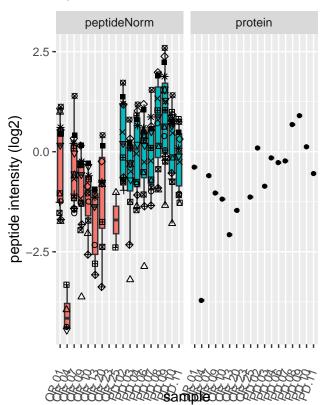








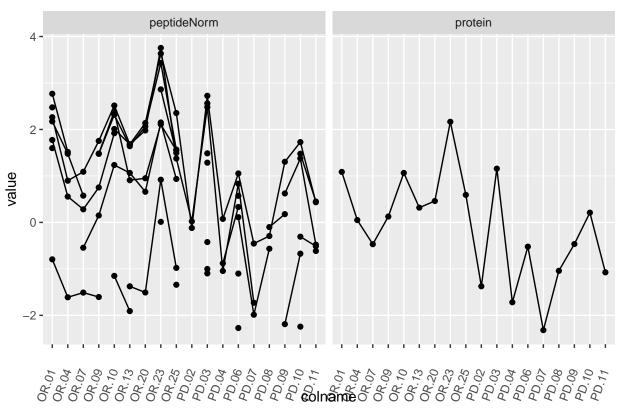


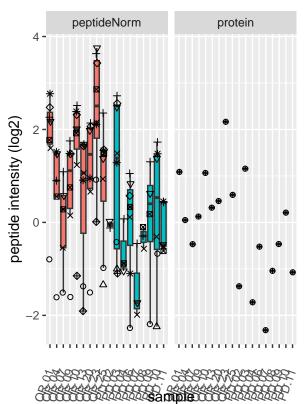




rowname

- EAEGAPQVEAGK
- △ EAEGAPQVEAGKR
- + EFDPTITDASLSLPSR
- × GNVFSSPTAAGTPNK
- ♦ LEQYTSAIEGTK
- PSDLRPGDVSSK
- * QKQEEESLGQVTDQVEVNAQNSVPDEEAK
- ♦ RGETESEEFEK
- ⊕ RRGETESEEFEK
- ☆ SAKPTKPAASDLPVPAEGVR
- STHQAAIVSK
- ▼ TTTTNTQVEGDDEAAFLER
- ☑ VLEEEEQR
- YEIEETETVTK





rowname

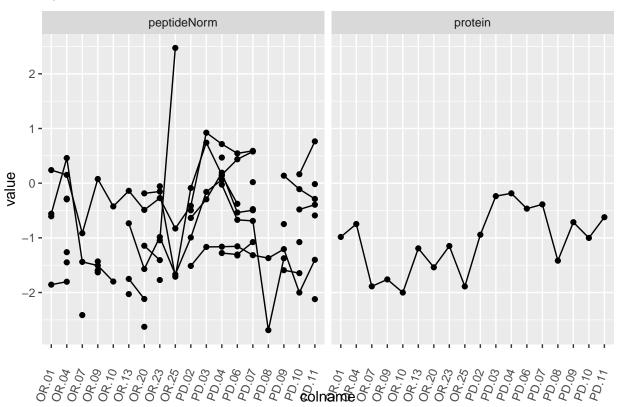
- APVAGTCYQAEWDDYVPK
- △ CDEPILSNR
- + GNDISSGTVLSDYVGSGPPK
- × LYEQLSGK
- ♦ LYTLVLTDPDAPSR
- ▽ NRPTSISWDGLDSGK
- VLTPTQVK
- * WSGPLSLQEVDEQPQHPLHVTYAGAAVDELGK
- ♦ YVWLVYEQDRPLK
- P30086

prognosis

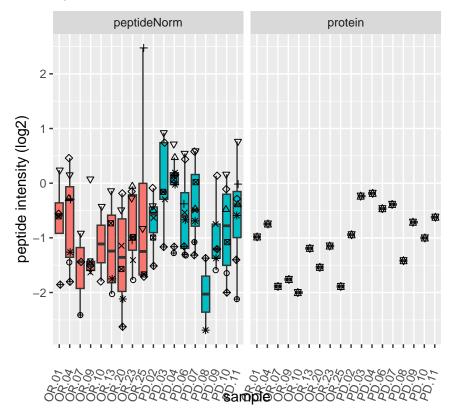


PD

Q9HAB8



Q9HAB8



rowname

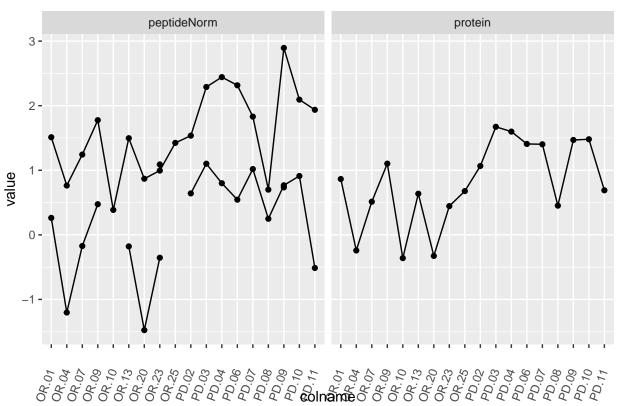
- AFIISFK
- △ FLDNFSSGR
- + IQSSGGPLQITMK
- × IVDNLQSR
- ♦ LETDPAIVINR
- □ LLLSEEEIEKGVEIEEK
- QSFVFIVTK
- * RVVLVTSGGTK
- ♦ VVLVTSGGTK
- ⊕ WAEVMAR
- ₩ Q9HAB8

prognosis

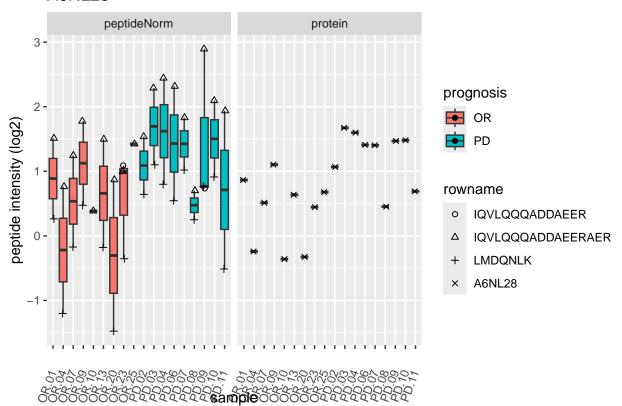


苗 PD

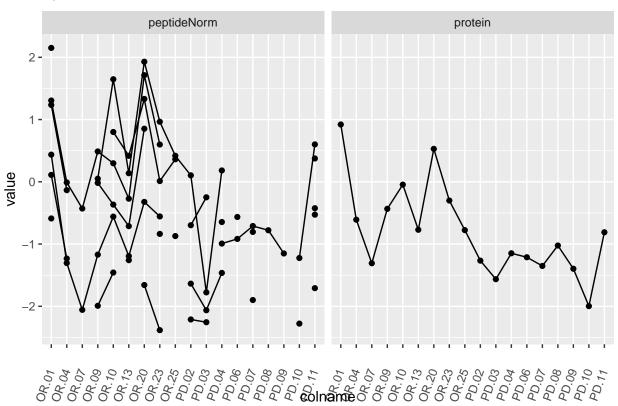
A6NL28



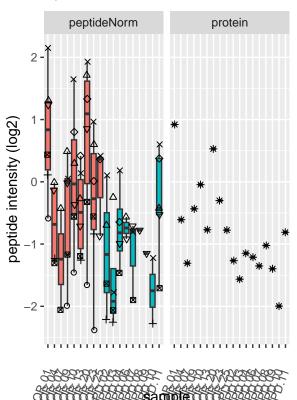
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Q9H936



Q9H936



rowname

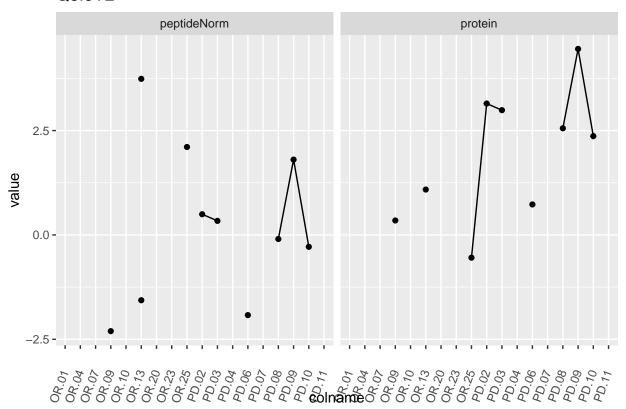
- DVPFSVVYFPLFANLNQLGRPASEEK
- GAAVNLTLVTPEK
- GLGATLLR +
- ILAAQGQLSAQGGAQPSVEAPAAPRPTATQLTR ×
- KILAAQGQLSAQGGAQPSVEAPAAPRPTATQLTR **\rightarrow**
- LAANDFFR ∇
- SEGYFGMYR ×
- Q9H936

prognosis

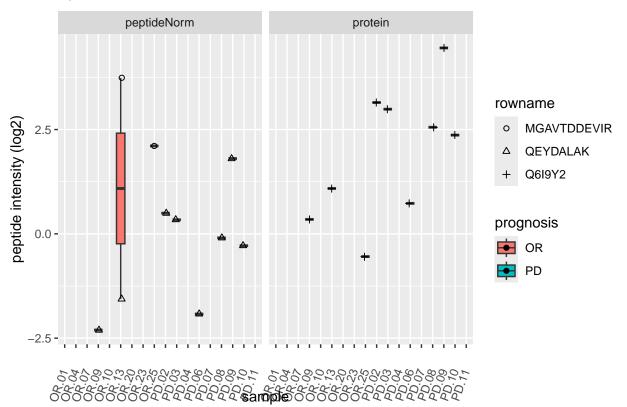




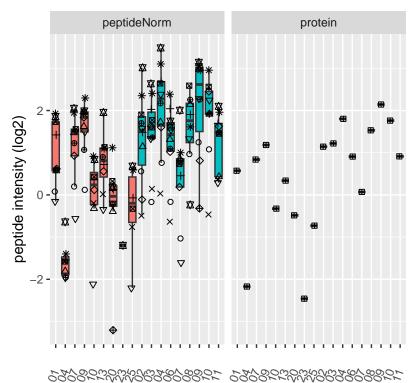
Q6I9Y2



Q6I9Y2







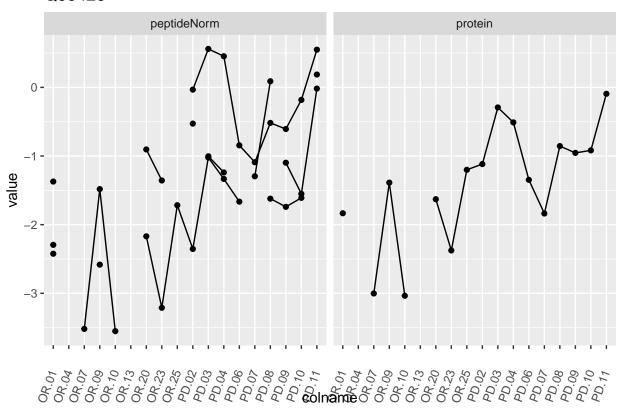
rowname

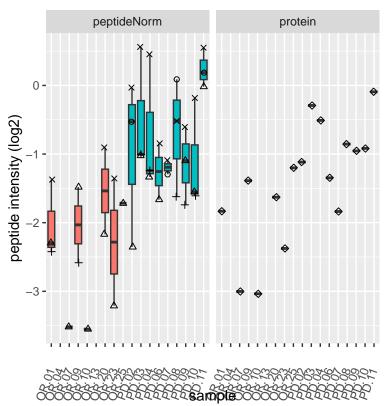
- AEGDVAALNR
- △ AGLNSLEAVK
- + AGLNSLEAVKR
- × CGDLEEELKNVTNNLK
- ♦ EENVGLHQTLDQTLNELNCI
- ▽ EKAEGDVAALNR
- IQALQQQADEAEDR
- * KIQALQQADEAEDR
- ◆ KLVILEGELERAEER
- ⊕ TIDDLEEK
- ☆ YSEKEDKYEEEIK
- **■** P67936

prognosis



PD PD





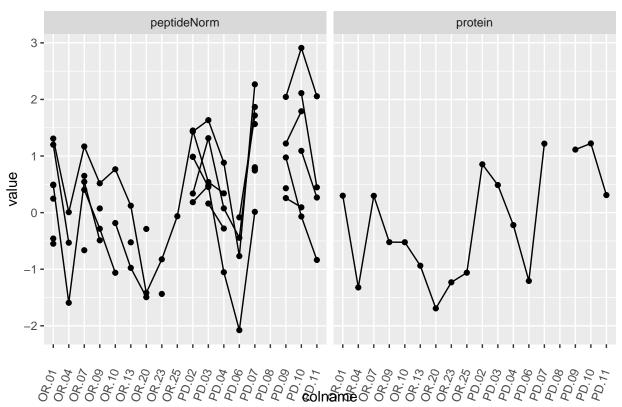
rowname

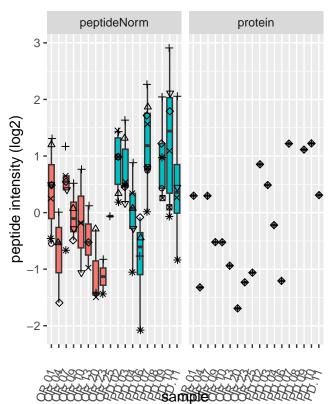
- LGEYEDVSR
- △ MEVTGVSAPTVTVFISSSLNTFR
- + YDEPLGK
- × YTISQEAYDQR
- ♦ Q99426

prognosis



pD





rowname

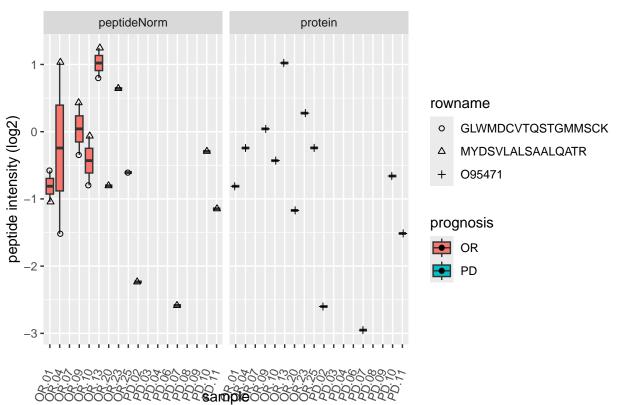
- DYFMPCPGR
- △ EVGTPHGIILDSVDAAFICPGSSR
- + LLQDEFPGIPSPLDAAVECHR
- × NFPSPVDAAFR
- ♦ SGAQATWTELPWPHEK
- ▼ SLGPNSCSANGPGLYLIHGPNLYCYSDVEK
- VDGALCMEK
- * YYCFQGNQFLR
- ♦ P02790

prognosis

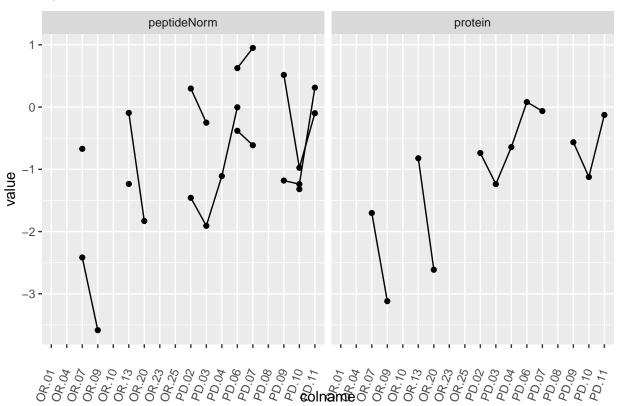


🖬 PD

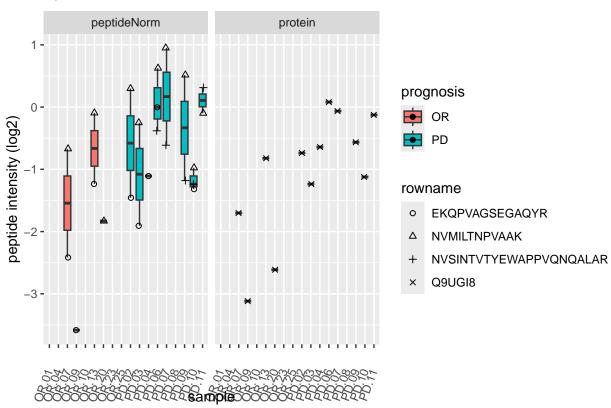


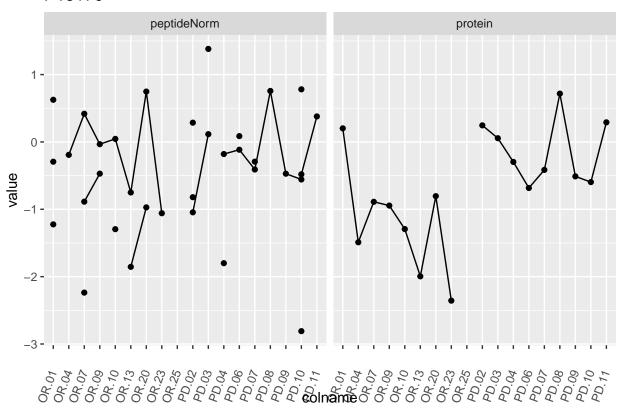


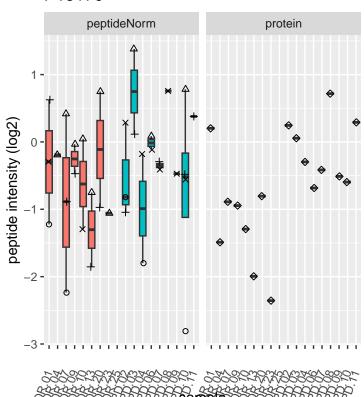
Q9UGI8



Q9UGI8







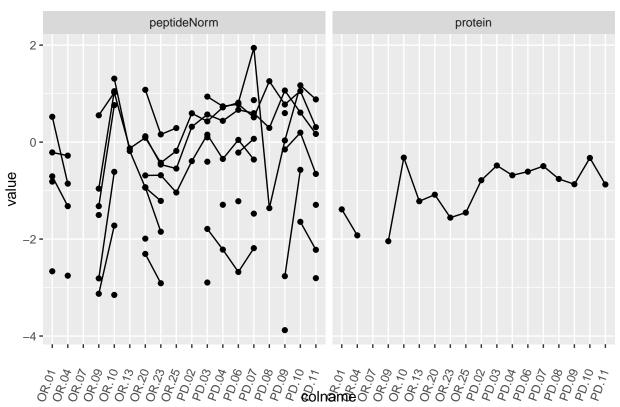
rowname

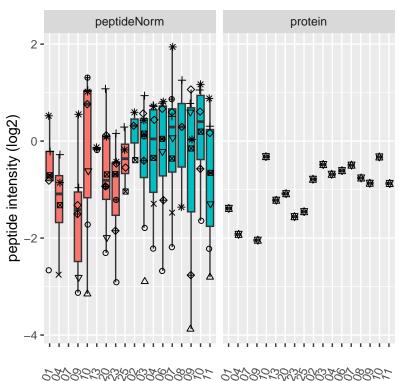
- AYFETEKK
- △ HNVEVLGILSDDVETDTVAPGENLK
- + STIGGQIMYLTGMVDKR
- × SVVAPPGAPK
- ♦ P15170

prognosis









rowname

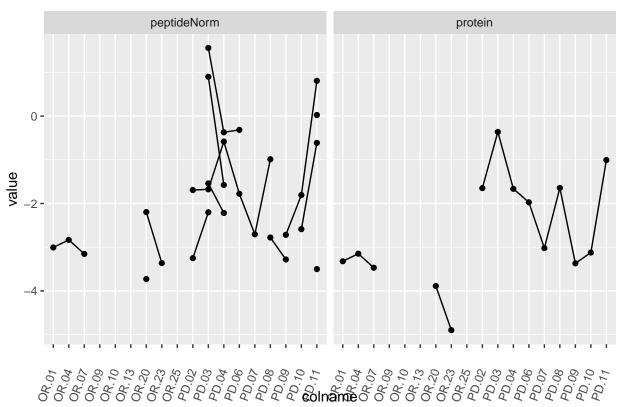
- DFSSVFQFLR
- DFSSVFQFLREEETF
- DLGLAQDSATSTK
- EFQDAGEQVVSSPADVAEK
- GSLLIDSSTIDPAVSK
- IITMLPTSINAIEAYSGANGILK
- × KGSLLIDSSTIDPAVSK
- MGAVFMDAPVSGGVGAAR
- SPILLGSLAHQIYR
- TPVGFIGLGNMGNPMAK

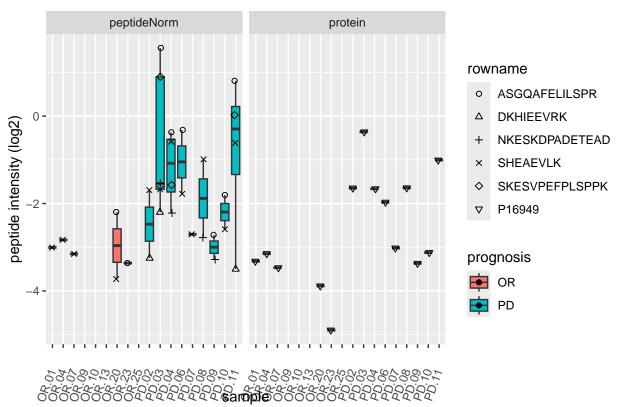
prognosis





PD PD

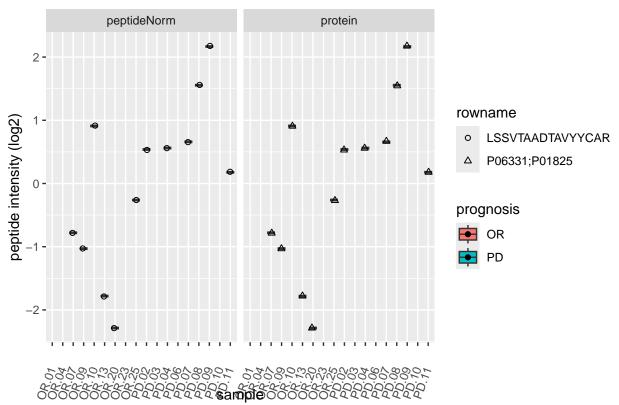




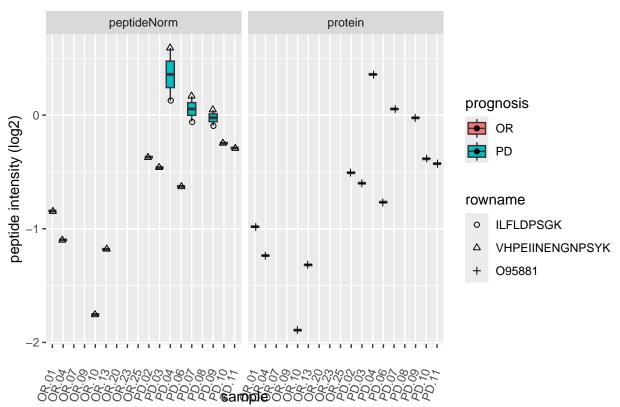
P06331;P01825

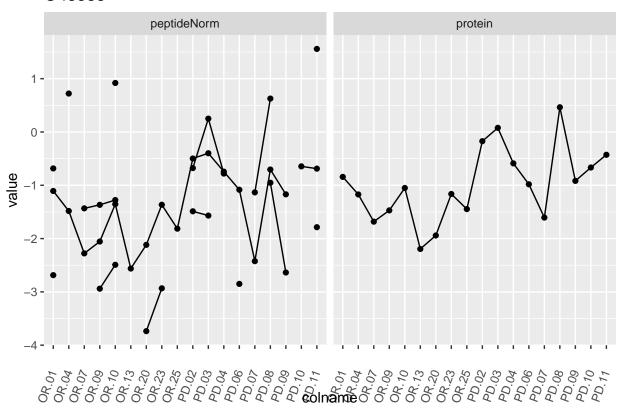


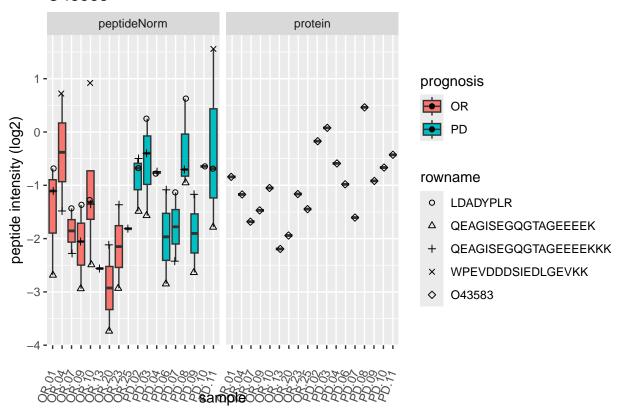
P06331;P01825

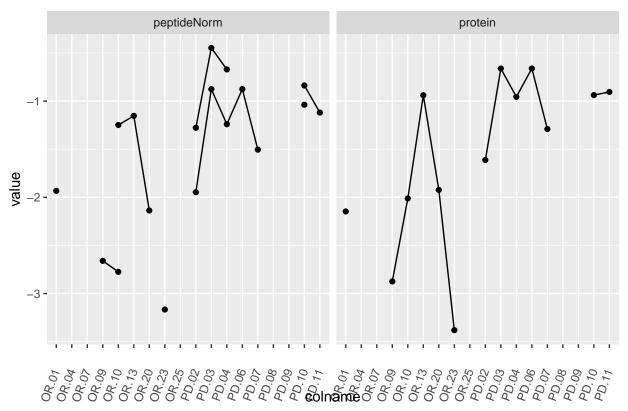


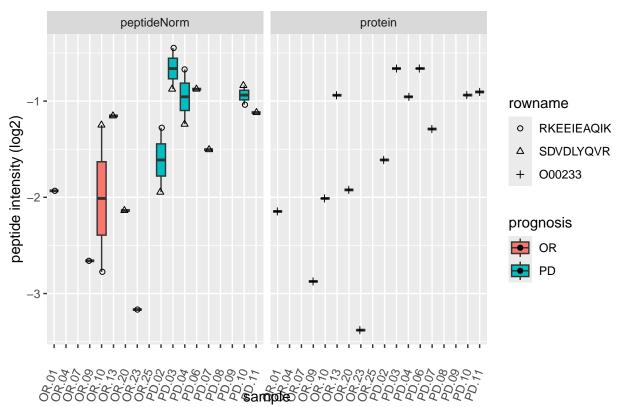


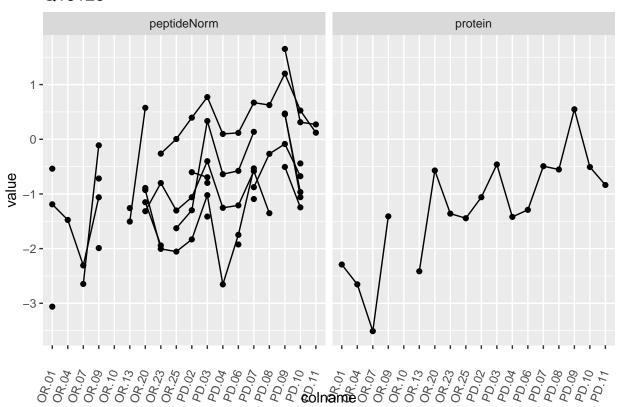


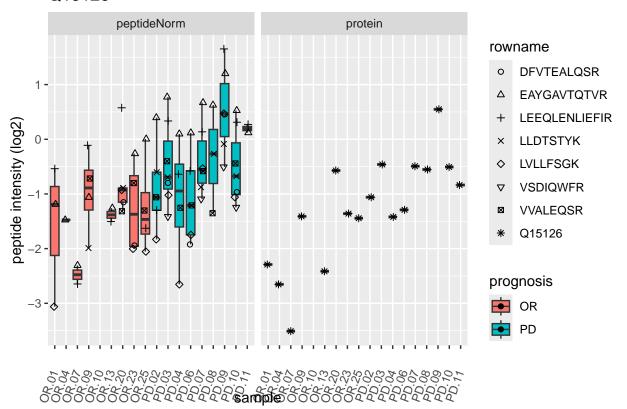












5 Session Info

With respect to reproducibility, it is highly recommended to include a session info in your script so that readers of your output can see your particular setup of R.

sessionInfo()

```
## R version 4.4.0 RC (2024-04-16 r86468)
## Platform: aarch64-apple-darwin20
## Running under: macOS Big Sur 11.6
##
## Matrix products: default
           /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRblas.0.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRlapack.dylib;
                                                                                                LAPACK v
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: Europe/Brussels
## tzcode source: internal
##
## attached base packages:
## [1] stats4
                 stats
                           graphics grDevices utils
                                                         datasets methods
## [8] base
##
## other attached packages:
```

```
[1] ExploreModelMatrix_1.16.0
                                     plotly_4.10.4
##
   [3] msqrob2_1.12.0
                                     QFeatures_1.14.1
  [5] MultiAssayExperiment 1.30.1 SummarizedExperiment 1.34.0
## [7] Biobase_2.64.0
                                     GenomicRanges_1.56.0
##
   [9] GenomeInfoDb 1.40.0
                                     IRanges_2.38.0
## [11] S4Vectors 0.42.0
                                     BiocGenerics 0.50.0
## [13] MatrixGenerics 1.16.0
                                     matrixStats 1.3.0
                                     lubridate_1.9.3
## [15] limma 3.60.4
## [17] forcats 1.0.0
                                     stringr_1.5.1
## [19] dplyr_1.1.4
                                     purrr_1.0.2
## [21] readr_2.1.5
                                     tidyr_1.3.1
## [23] tibble_3.2.1
                                     ggplot2_3.5.1
## [25] tidyverse_2.0.0
##
## loaded via a namespace (and not attached):
## [1] rlang_1.1.3
                                 magrittr_2.0.3
                                                          shinydashboard_0.7.2
                                                          vctrs_0.6.5
## [4] clue_0.3-65
                                 compiler_4.4.0
## [7] reshape2_1.4.4
                                 ProtGenerics 1.36.0
                                                         pkgconfig_2.0.3
## [10] crayon_1.5.2
                                 fastmap_1.2.0
                                                         XVector_0.44.0
## [13] fontawesome 0.5.2
                                 labeling_0.4.3
                                                         utf8 1.2.4
## [16] promises_1.3.0
                                 rmarkdown_2.28
                                                         tzdb_0.4.0
## [19] UCSC.utils_1.0.0
                                 nloptr_2.0.3
                                                         xfun 0.44
## [22] zlibbioc_1.50.0
                                 cachem_1.0.8
                                                          jsonlite_1.8.8
## [25] later 1.3.2
                                 highr 0.11
                                                         DelayedArray 0.30.1
## [28] BiocParallel 1.38.0
                                 parallel_4.4.0
                                                          cluster 2.1.6
## [31] R6_2.5.1
                                 bslib_0.7.0
                                                          stringi_1.8.4
## [34] boot_1.3-30
                                                         Rcpp_1.0.12
                                 jquerylib_0.1.4
## [37] knitr_1.48
                                 BiocBaseUtils_1.6.0
                                                         httpuv_1.6.15
## [40] Matrix_1.7-0
                                 splines_4.4.0
                                                          igraph_2.0.3
## [43] timechange_0.3.0
                                                         rstudioapi_0.16.0
                                 tidyselect_1.2.1
## [46] abind_1.4-5
                                 yaml_2.3.8
                                                          codetools_0.2-20
## [49] lattice_0.22-6
                                 plyr_1.8.9
                                                          shiny_1.8.1.1
## [52] withr_3.0.0
                                 evaluate_0.23
                                                         pillar_1.9.0
## [55] DT_0.33
                                 shinyjs_2.1.0
                                                         generics_0.1.3
## [58] hms 1.1.3
                                                          scales 1.3.0
                                 munsell_0.5.1
## [61] minqa_1.2.6
                                 xtable_1.8-4
                                                         glue_1.7.0
## [64] lazyeval 0.2.2
                                 tools 4.4.0
                                                         data.table 1.15.4
## [67] lme4_1.1-35.3
                                                          grid_4.4.0
                                 cowplot_1.1.3
## [70] MsCoreUtils_1.16.0
                                 colorspace_2.1-0
                                                         nlme_3.1-164
## [73] GenomeInfoDbData_1.2.12 cli_3.6.2
                                                          fansi_1.0.6
## [76] S4Arrays 1.4.0
                                 viridisLite 0.4.2
                                                          AnnotationFilter 1.28.0
## [79] gtable_0.3.5
                                 rintrojs_0.3.4
                                                          sass_0.4.9
## [82] digest_0.6.35
                                 SparseArray_1.4.3
                                                         htmlwidgets_1.6.4
## [85] farver_2.1.2
                                 htmltools_0.5.8.1
                                                         lifecycle_1.0.4
## [88] httr_1.4.7
                                 mime_0.12
                                                         statmod_1.5.0
```

[91] MASS_7.3-60.2