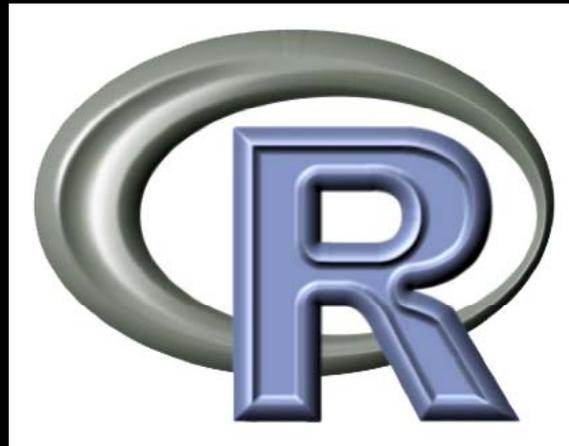


Introduction to R Graphics:

Using R to create figures



BaRC Hot Topics – October 2011

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<http://iona.wi.mit.edu/bio/education/R2011/>



Topics for today

- Getting started with R
- Drawing common types of plots (scatter, box, MA)
- Comparing distributions (histograms, CDF plots)
- Customizing plots (colors, points, lines, margins)
- Combining plots on a page
- Combining plots on top of each other
- More specialized figures and details



Why use R for graphics?

- Creating custom publication-quality figures
- Many figures take only a few commands
- Almost complete control over every aspect of the figure
- To automate figure-making (and make them more reproducible)
- Real statisticians use it
- It's free



Why not use R for graphics?

- Another application already works fine
- It's hard to use at first
 - You have to know what commands to use
- Getting the exact figure you want can take a series of commands
- Final product is editable only in Illustrator
- Real statisticians use it



Getting started

- See previous session: Introduction to R:
<http://iona.wi.mit.edu/bio/education/R2011/>
- Hot Topics slides:
http://iona.wi.mit.edu/bio/hot_topics/
- R can be run on your computer or on tak.



Start of an R session

On tak

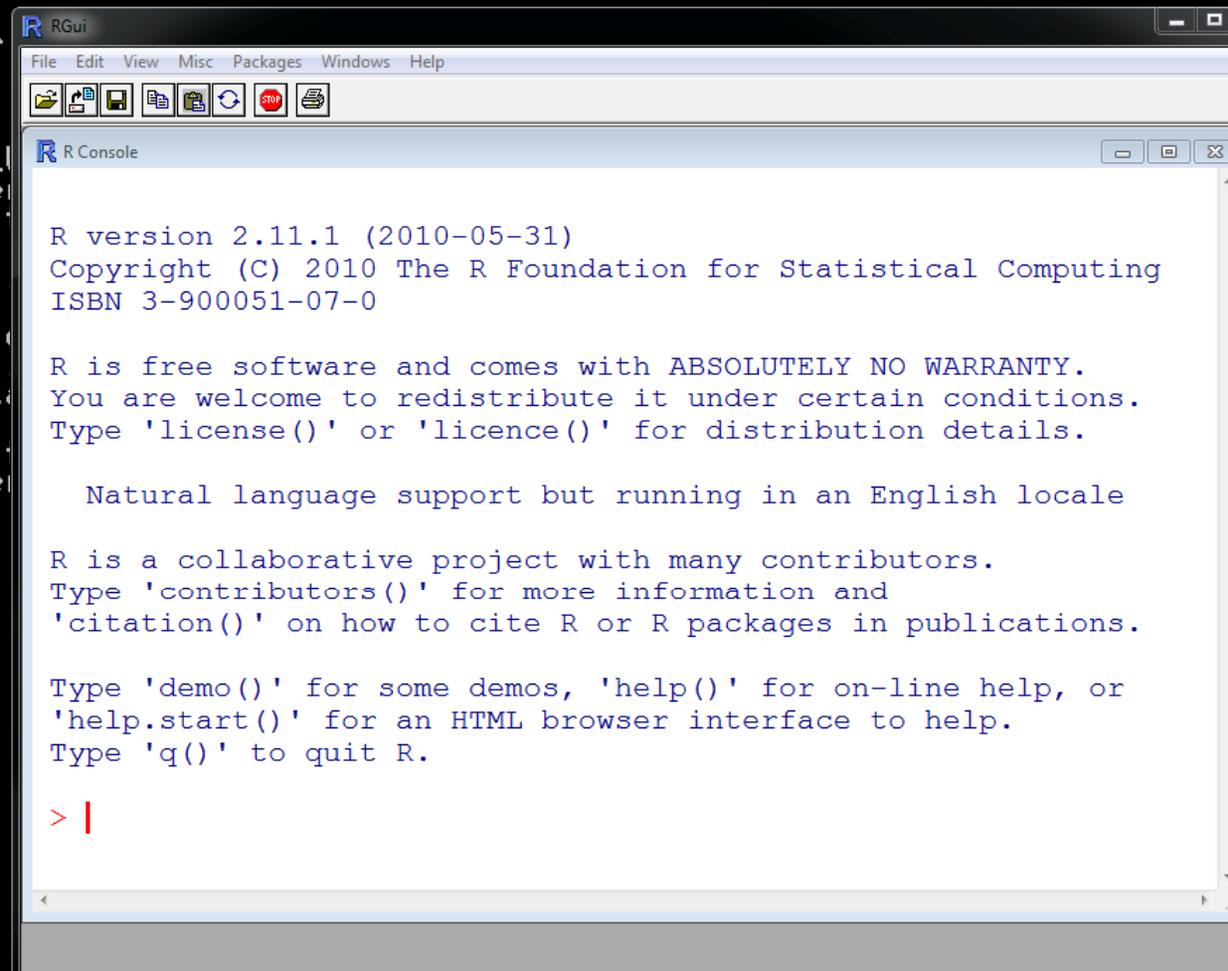
On your own computer

```
gbell@tak ~$ R
R version 2.12.1 (2010-12-16)
Copyright (C) 2010 The R Foundation for
ISBN 3-900051-07-0
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLU
You are welcome to redistribute it unde
Type 'license()' or 'licence()' for dist

Natural language support but running

R is a collaborative project with many
Type 'contributors()' for more informat
'citation()' on how to cite R or R packa
Type 'demo()' for some demos, 'help()'
'help.start()' for an HTML browser inter
Type 'q()' to quit R.
>
```



The screenshot shows the R GUI window with the R Console pane. The console displays the following text:

```
R version 2.11.1 (2010-05-31)
Copyright (C) 2010 The R Foundation for Statistical Computing
ISBN 3-900051-07-0

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

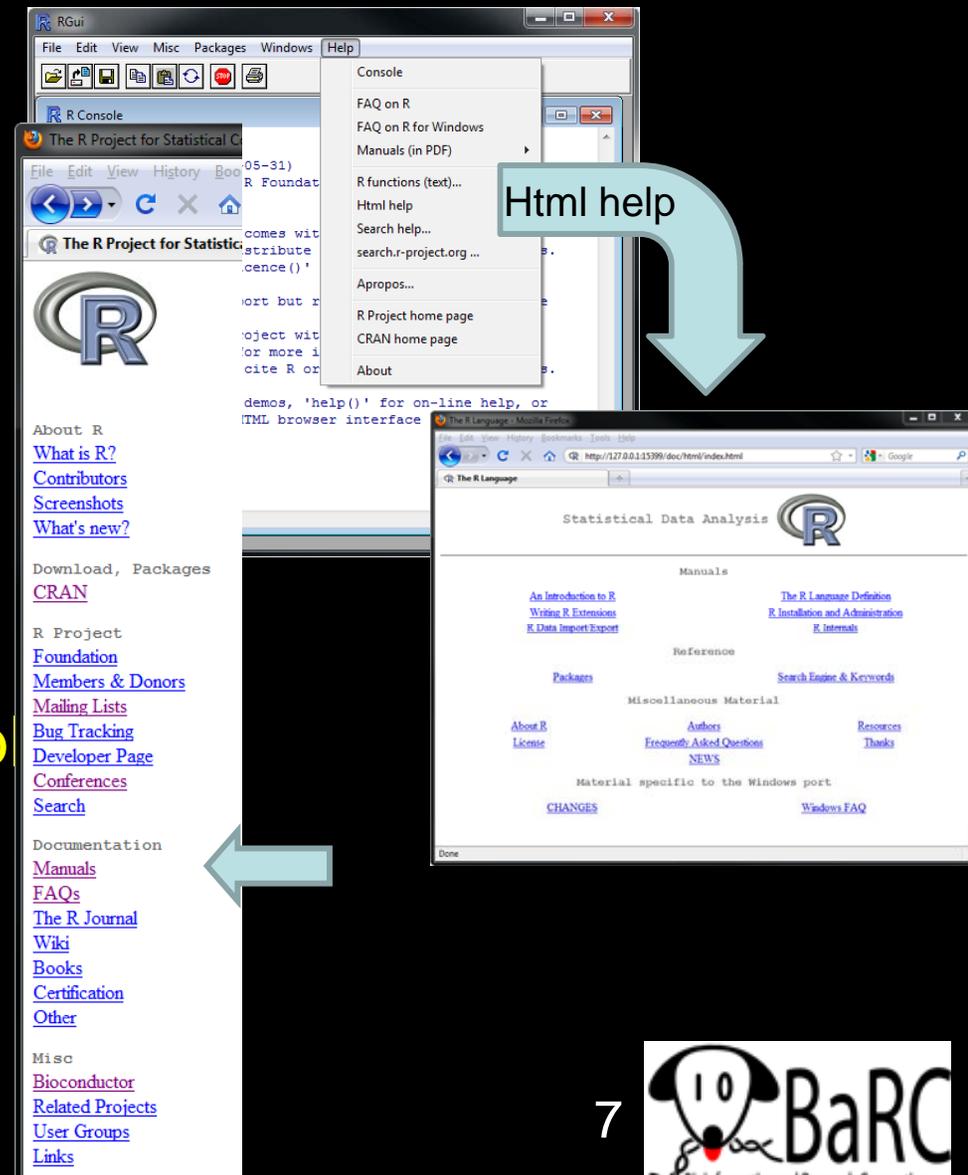
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> |
```

Getting help

- Use the Help menu
- Check out “Manuals”
 - <http://www.r-project.org/>
 - contributed documentation
- Use R’s help
 - ?boxplot [show info]
 - ??boxplot [search docs]
 - example(boxplot) [example]
- Search the web
 - “r-project boxplot”

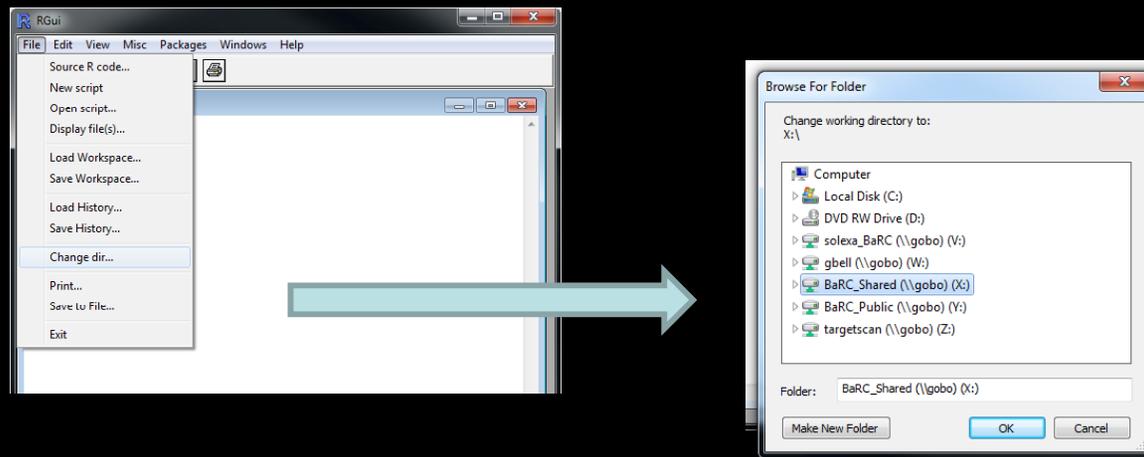


The image shows two overlapping screenshots. The top screenshot is the RGui application window with the Help menu open. The menu items include: Console, FAQ on R, FAQ on R for Windows, Manuals (in PDF), R functions (text...), Html help, Search help..., search.r-project.org..., Apropos..., R Project home page, CRAN home page, and About. A blue arrow points from the 'Html help' option to a browser window below. The bottom screenshot shows the R Project website (http://127.0.0.1:15399/doc/html/index.html) with a navigation menu. The menu includes: About R, What is R?, Contributors, Screenshots, What's new?, Download, Packages, CRAN, R Project, Foundation, Members & Donors, Mailing Lists, Bug Tracking, Developer Page, Conferences, Search, Documentation, Manuals, FAQs, The R Journal, Wiki, Books, Certification, Other, Misc, Bioconductor, Related Projects, User Groups, and Links. A blue arrow points from the 'Manuals' link in the website menu to the 'Manuals' section of the website content.



Reading files - intro

- Take R to your preferred directory ()



- Check where you are (e.g., get your working directory) and see what files are there

```
> getwd()
```

```
[1] "X:/bell/Hot_Topics/Intro_to_R"
```

```
> dir()
```

```
[1] "all_my_data.txt"
```



Reading data files

- Usually it's easiest to read data from a file
 - Organize in Excel with one-word column names
 - Save as tab-delimited text

- Check that file is there

```
list.files()
```

- Read file

```
tumors = read.delim("tumors_wt_ko.txt", header=T)
```

- Check that it's OK

```
> tumors
  wt ko
1  5  8
2  6  9
3  7 11
```

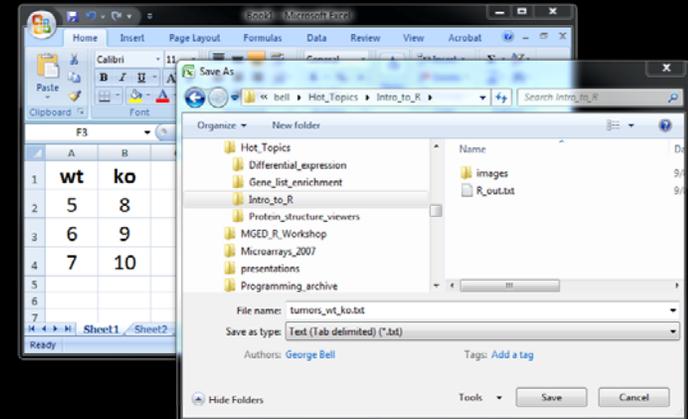


Figure formats and sizes

- By default, a figure window will pop up from most R sessions.
- Instead, helpful figure names can be included in code
 - Pro: You won't need an extra step to save the figure
 - Con: You won't see what you're creating
- To select name and size (in inches) of pdf file (which can be >1 page)

```
pdf("tumor_boxplot.pdf", w=11, h=8.5)
boxplot(tumors)           # can have >1 page
dev.off()                 # tell R that we're done
```
- To create another format (with size in pixels)

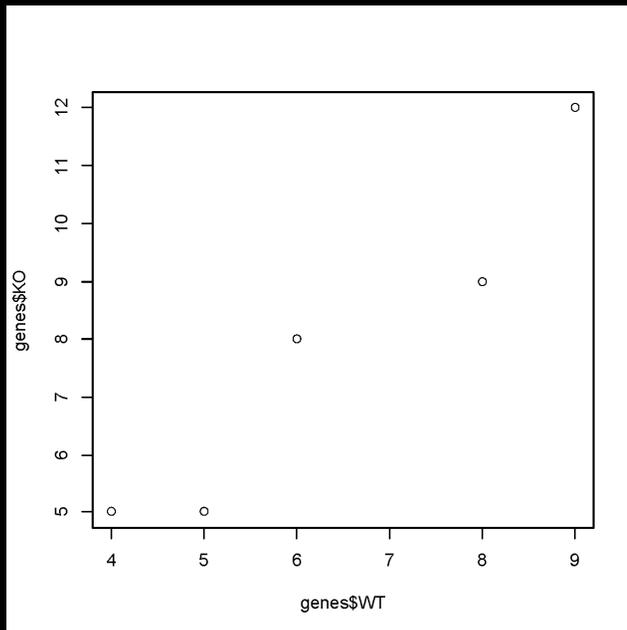
```
png("tumor_boxplot.png", w=1800, h=1200)
boxplot(tumors)
dev.off()
```
- Save your commands (in a text file)!
- Final PDF figures
 - can be converted with Acrobat
 - are be edited with Illustrator



Introduction to scatterplots

- Simplest use of the 'plot' command
- Can draw any number of points
- Example (comparison of expression values)

```
genes = read.delim("Gene_exp_with_sd.txt")  
plot(genes$WT, genes$KO)
```



Gene	WT	KO
A	6	8
B	5	5
C	9	12
D	4	5
E	8	9
F	6	8

But note that A = F

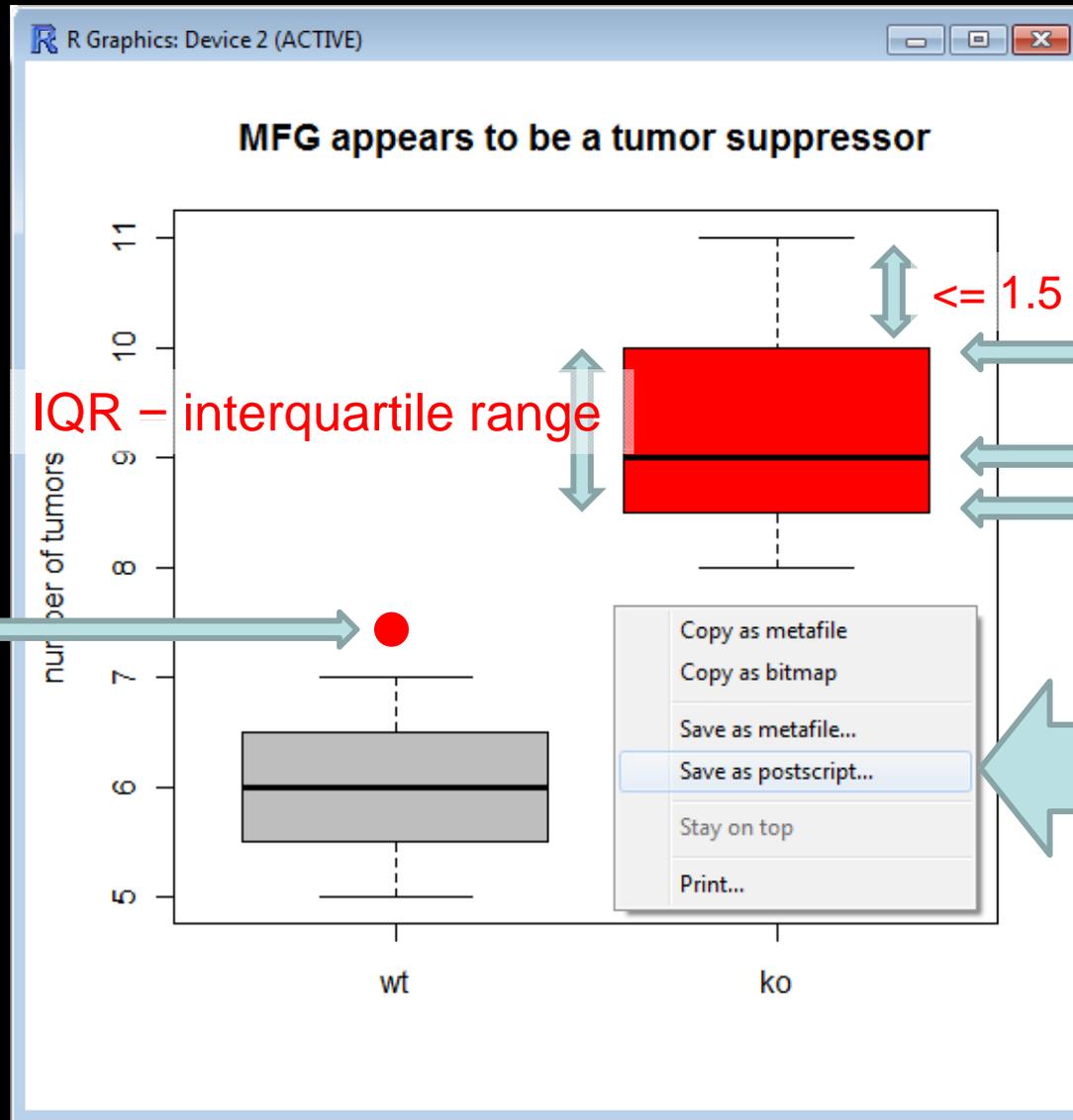


Boxplot conventions

wt	ko
5	8
6	9
7	11

Any points beyond the whiskers are defined as "outliers".

Note that the above data has no "outliers". The red point was added by hand.

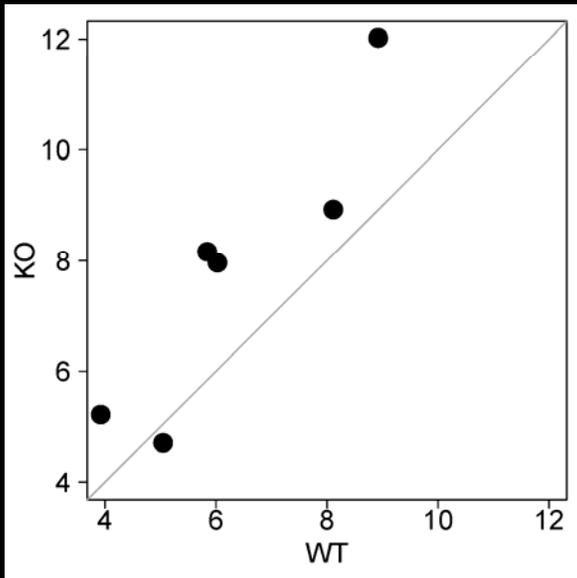


Other programs use different conventions!

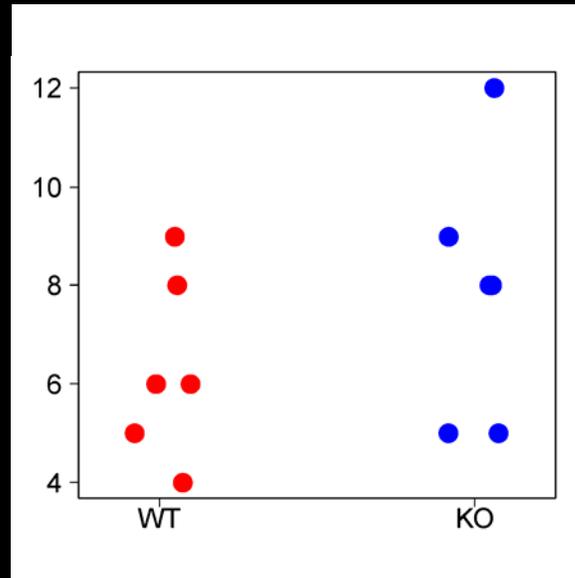


Comparing sets of numbers

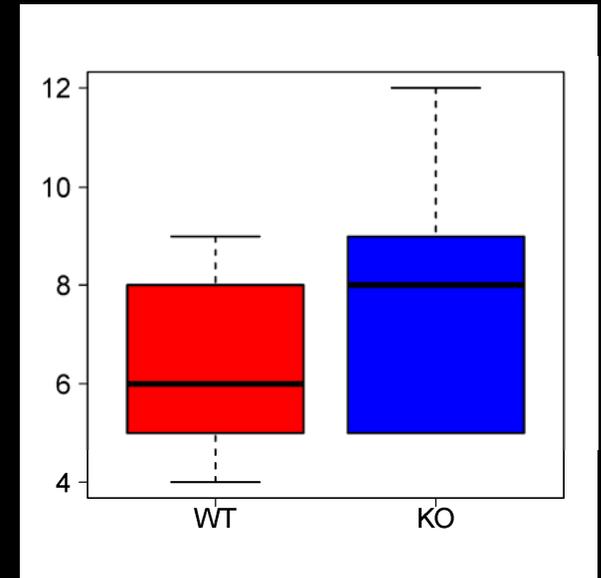
- Why are you making the figure?
- What is it supposed to show?
- How much detail is best?
- Are the data points paired?



`plot(genes)`



`stripchart(genes, vert=T)`



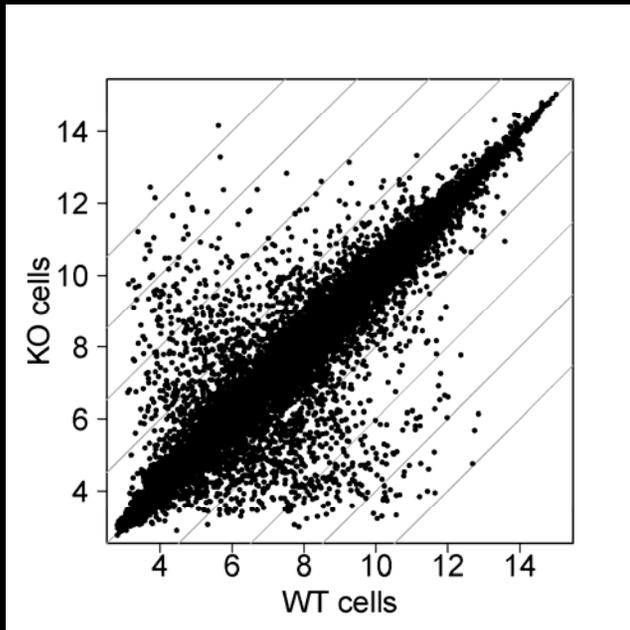
`boxplot(genes)`

Note the “jitter” (addition of noise) in the first 2 figures.



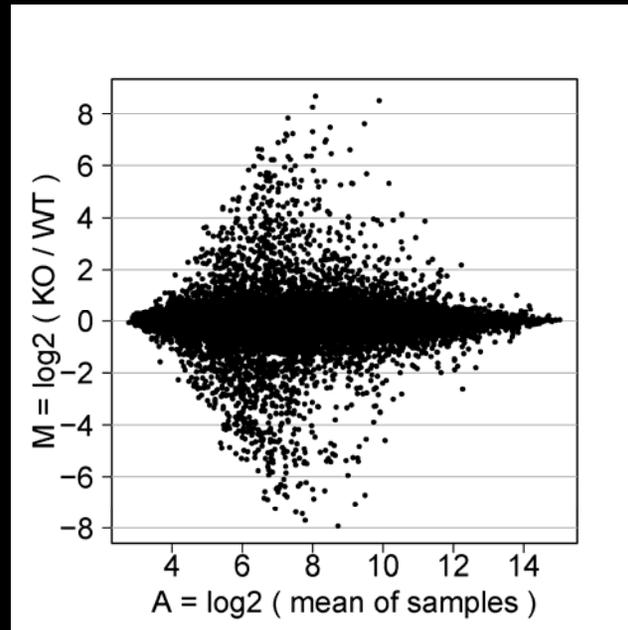
Gene expression plots

Typical x-y scatterplot



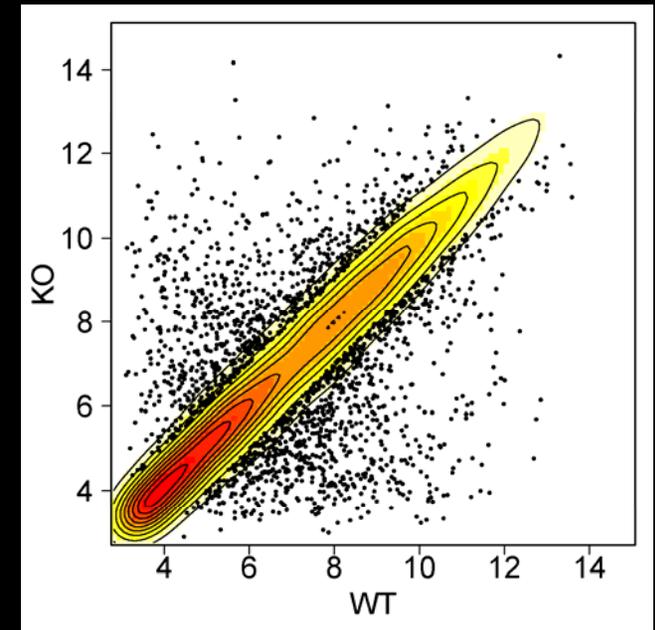
```
plot(genes.all)
abline(0,1)
# Add other lines
```

MA (ratio-intensity) plot



```
M = genes.all[,2] - genes.all[,1]
A = apply(genes.all, 1, mean)
plot(A,M)
# etc.
```

x-y scatterplot with contour



```
library(MASS)
kde2d() # et density
image() # Draw colors
contour() # Add contour
points() # Add points
```



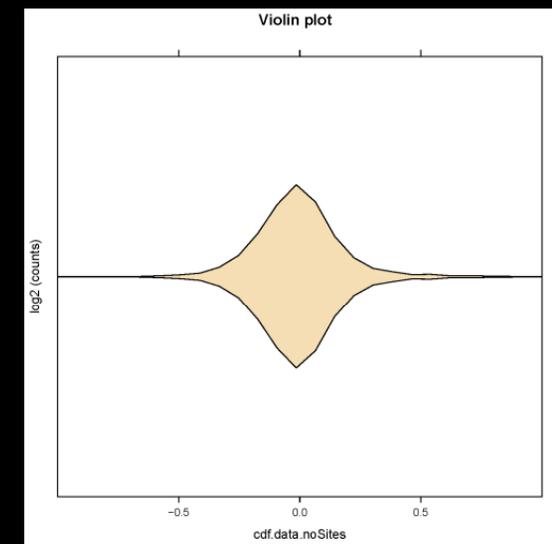
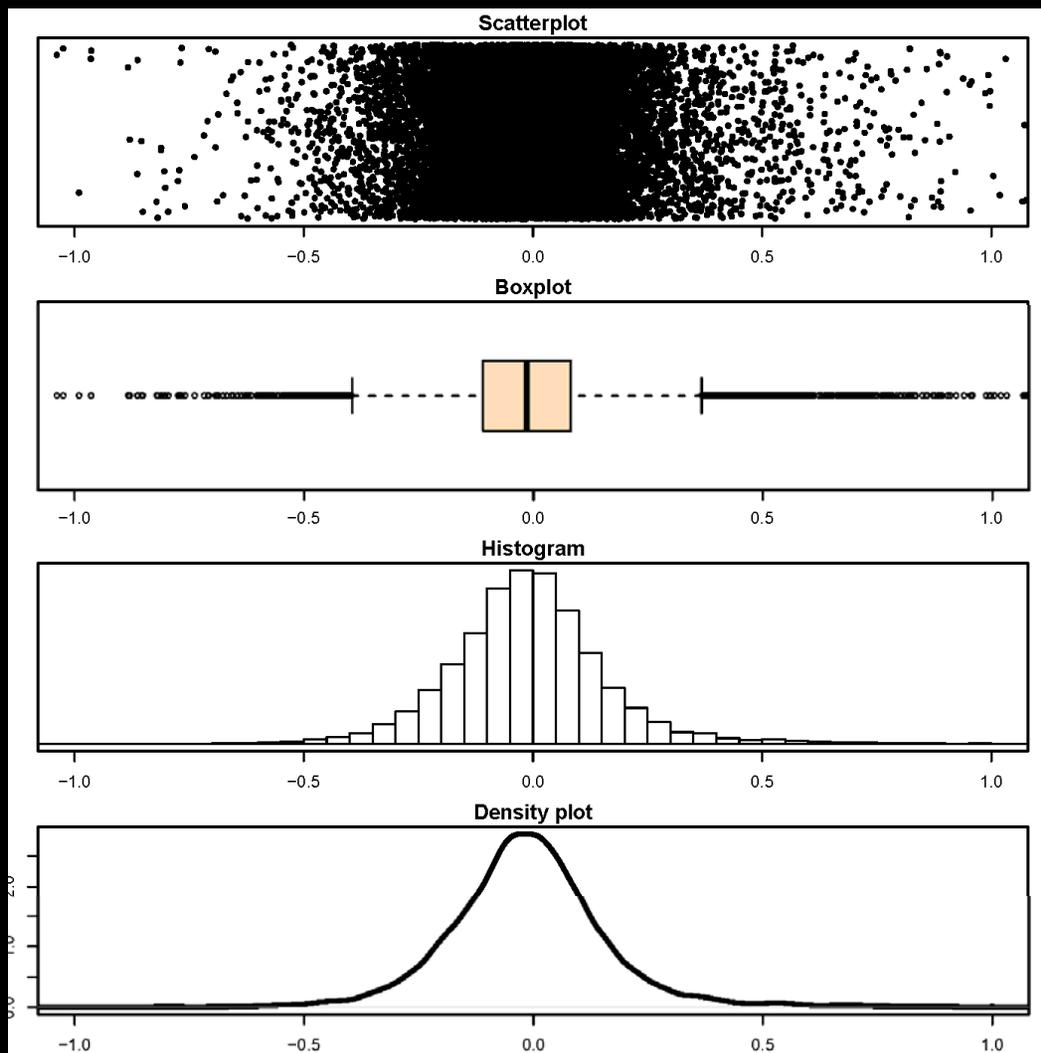
Comparing distributions

- Why are you making the figure?
- What is it supposed to show?
- How much detail is best?
- Methods:
 - Boxplot
 - Histogram
 - Density plot
 - Violin plot
 - CDF (cumulative distribution function) plot



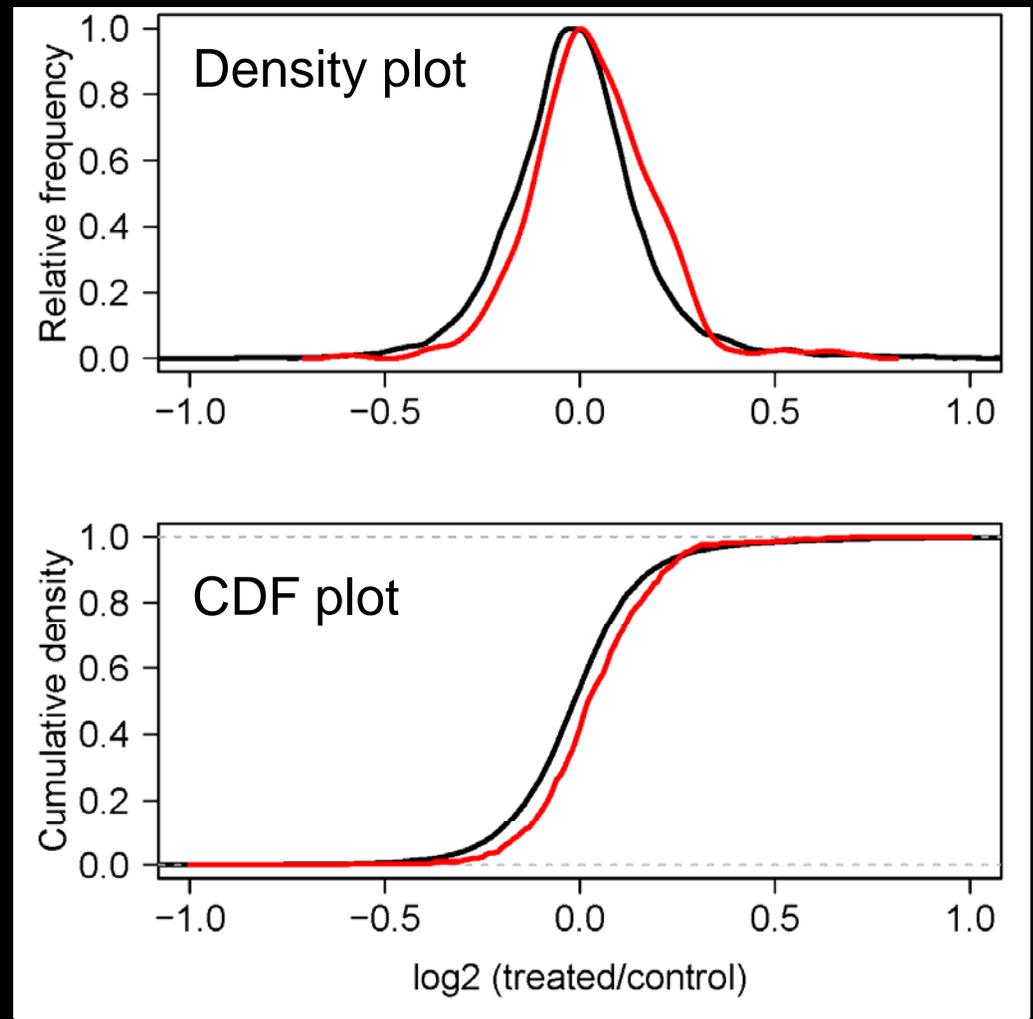
Displaying distributions

- Example dataset: log₂ expression ratios



Comparing similar distributions

- Example dataset:
 - MicroRNA is knocked down
 - Expression levels are assayed
 - Genes are divided into those without miRNA target site (black) vs. with target site (red)



Customizing plots

- About anything about a plot can be modified, although it can be tricky to figure out how to do so.
 - Colors `ex: col="red"`
 - Shapes of points `ex: pch=18`
 - Shapes of lines `ex: lwd=3, lty=3`
 - Axes (labels, scale, orientation, size)
 - Margins `see 'mai' in par()`
 - Additional text `ex: text(2, 3, "This text")`
 - See `par()` for a lot more options



Point shapes by number

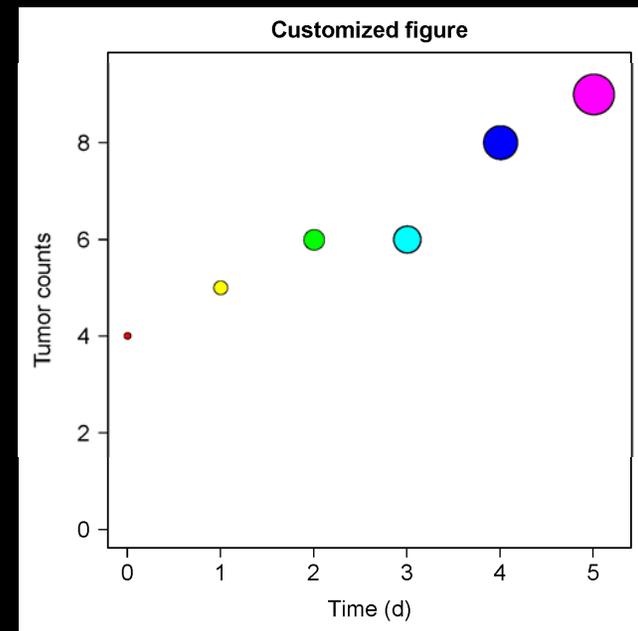
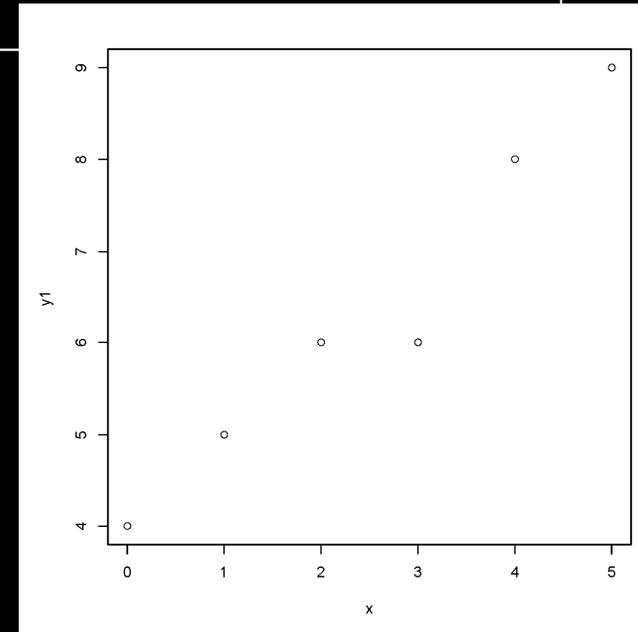
Ex:

pch=21

0		6		12		18		24		0	
1		7		13		19		25		+	
2		8		14		20		*		-	
3		9		15		21		.			
4		10		16		22		o		%	
5		11		17		23		o		#	

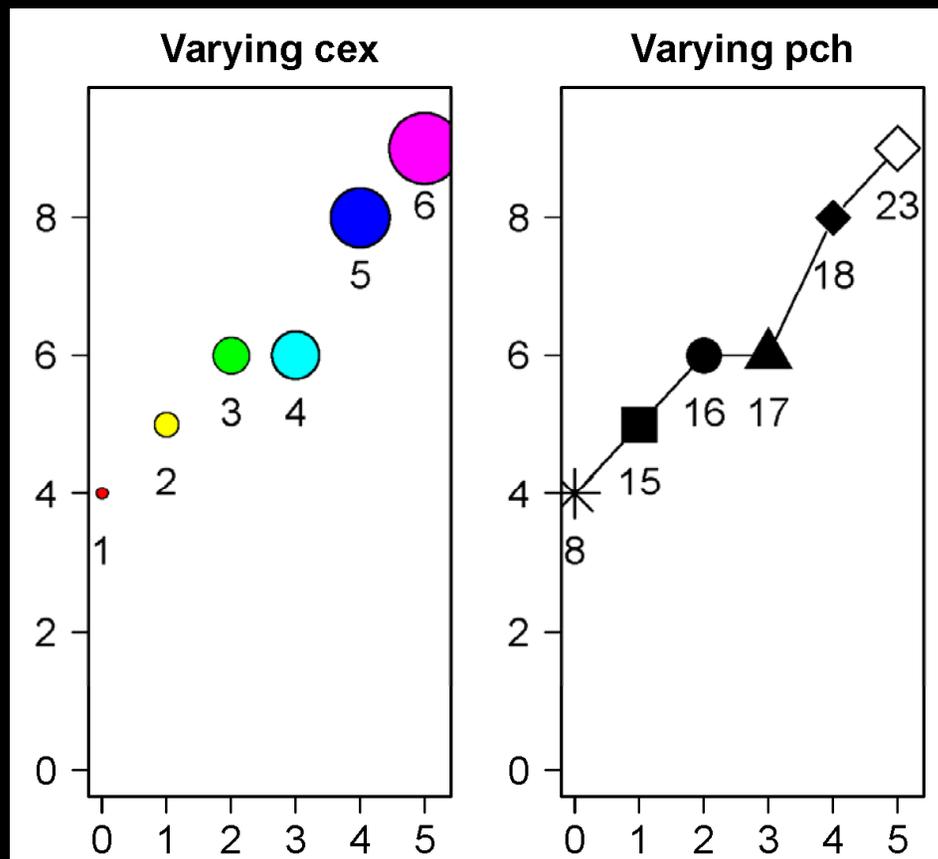
Customizing a plot

- `plot(x, y, type="p")`
- `plot(x, y, type="p", pch=21, col="black", bg=rainbow(6), cex=x+1, ylim=c(0, max(c(y1,y2))), xlab="Time (d)", ylab="Tumor counts", las=1, cex.axis=1.5, cex.lab=1.5, main="Customized figure", cex.main=1.5)`
- Non-obvious options:
 - `type="p"` # Draw points
 - `pch=21` # Draw a 2-color circle
 - `col="black"` # Outside color of points
 - `bg=rainbow(6)` # Inside color of points
 - `cex=x+1` # Size points using 'x'
 - `las=1` # Print horizontal axis labels



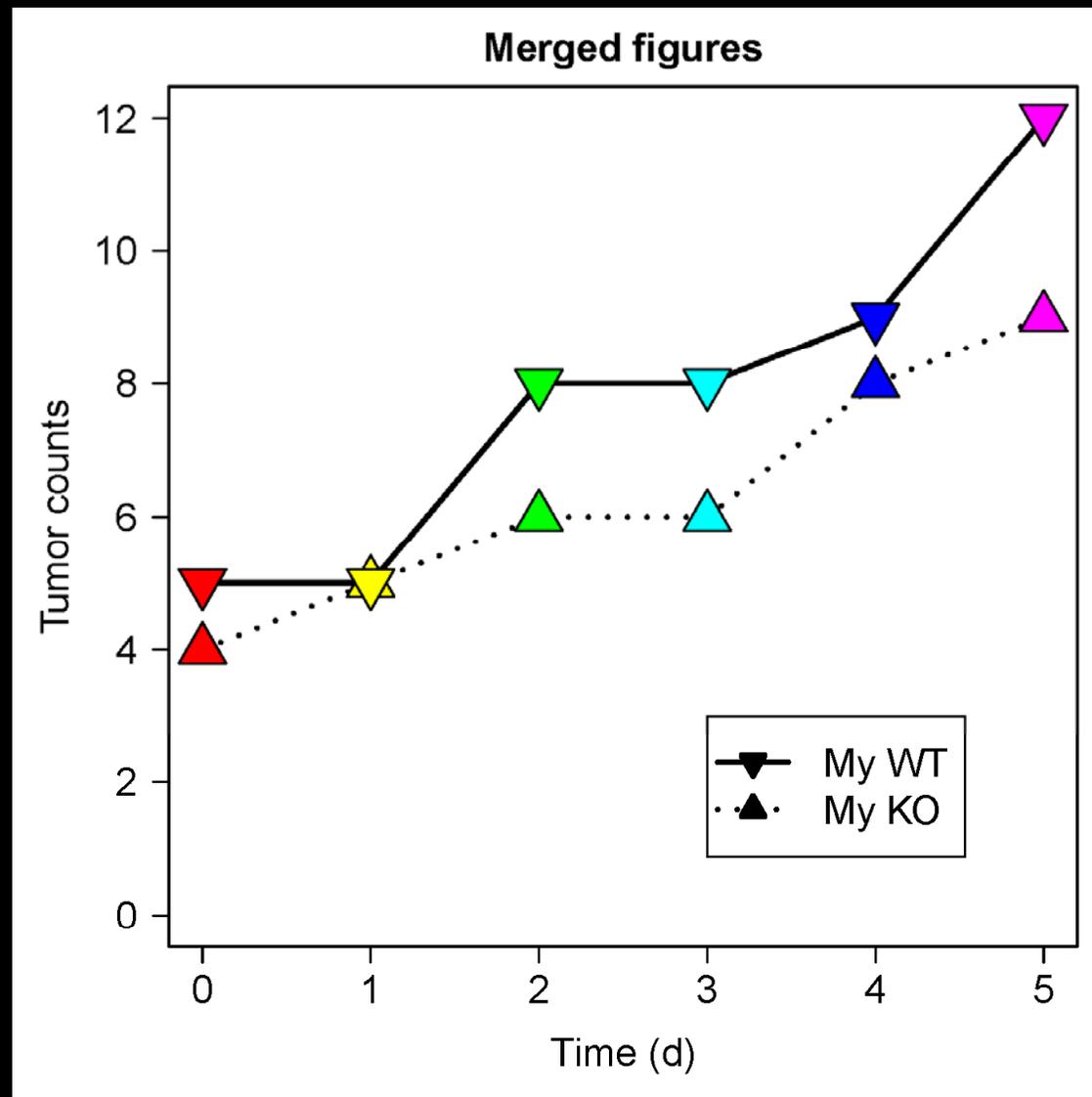
Combining plots on a page

- Set up layout with command like
 - `par(mfrow = c(num.rows, num.columns))`
 - Ex: `par(mfrow = c(1,2))`



Merging plots on same figure

- **Commands:**
 - plot # start figure
 - points # add point(s)
 - lines # add line(s)
 - legend
- Note that order of commands determines order of layers



More graphics details

- Creating error bars
- Drawing a best-fit (regression) line
- Using transparent colors
- Creating colored segments
- Creating log-transformed axes
- Labeling selected points



Using error bars

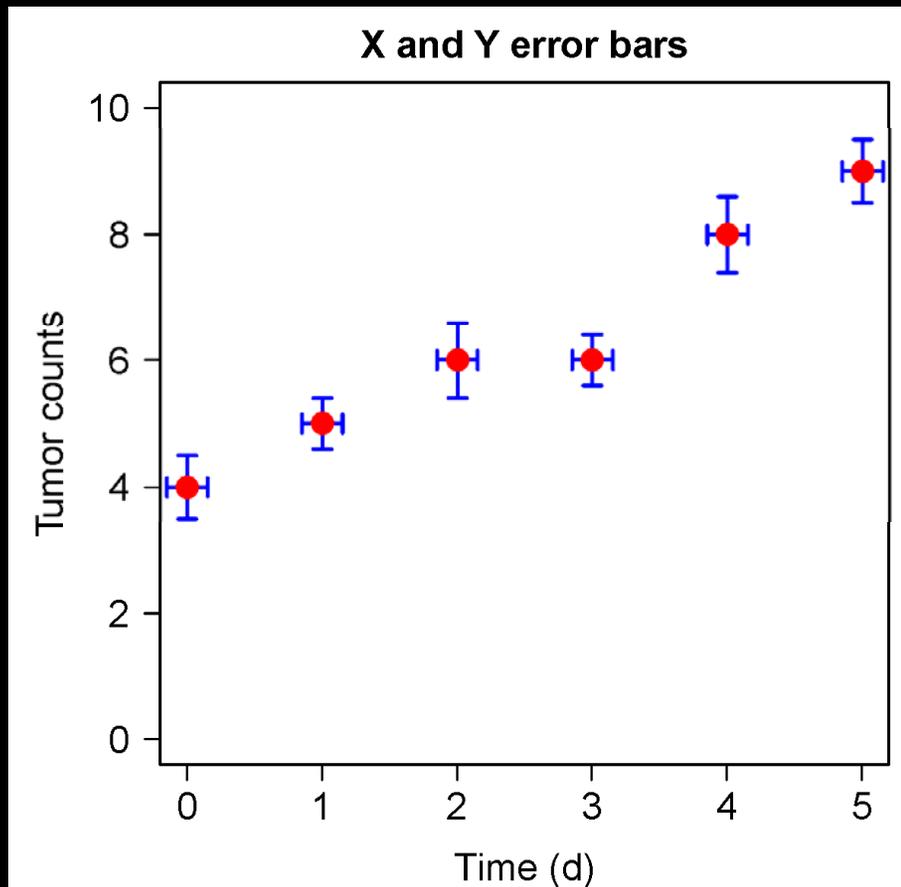
```
library(plotrix)
```

```
plotCI(x, y, uiw=y.sd, liw=y.sd)
```

vertical error bars

```
plotCI(x, y, uiw=x.sd, liw=x.sd, err="x", add=T)
```

horizontal



Drawing a regression line

- Use 'lm(response~terms)' for simple linear regression:

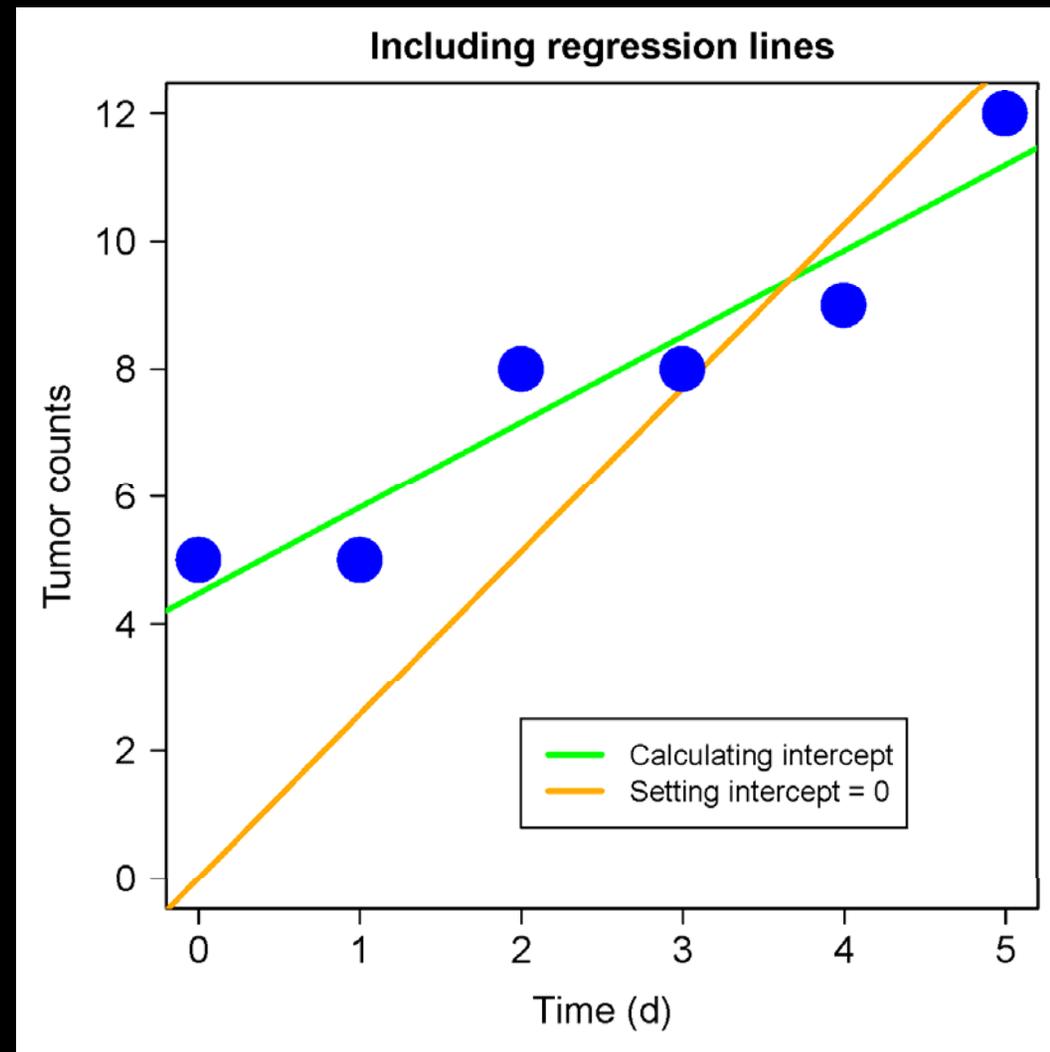
```
# Calculate y-intercept
```

```
lmfit = lm(y ~ x)
```

```
# Set y-intercept to 0
```

```
lmfit.0 = lm(y ~ x + 0)
```

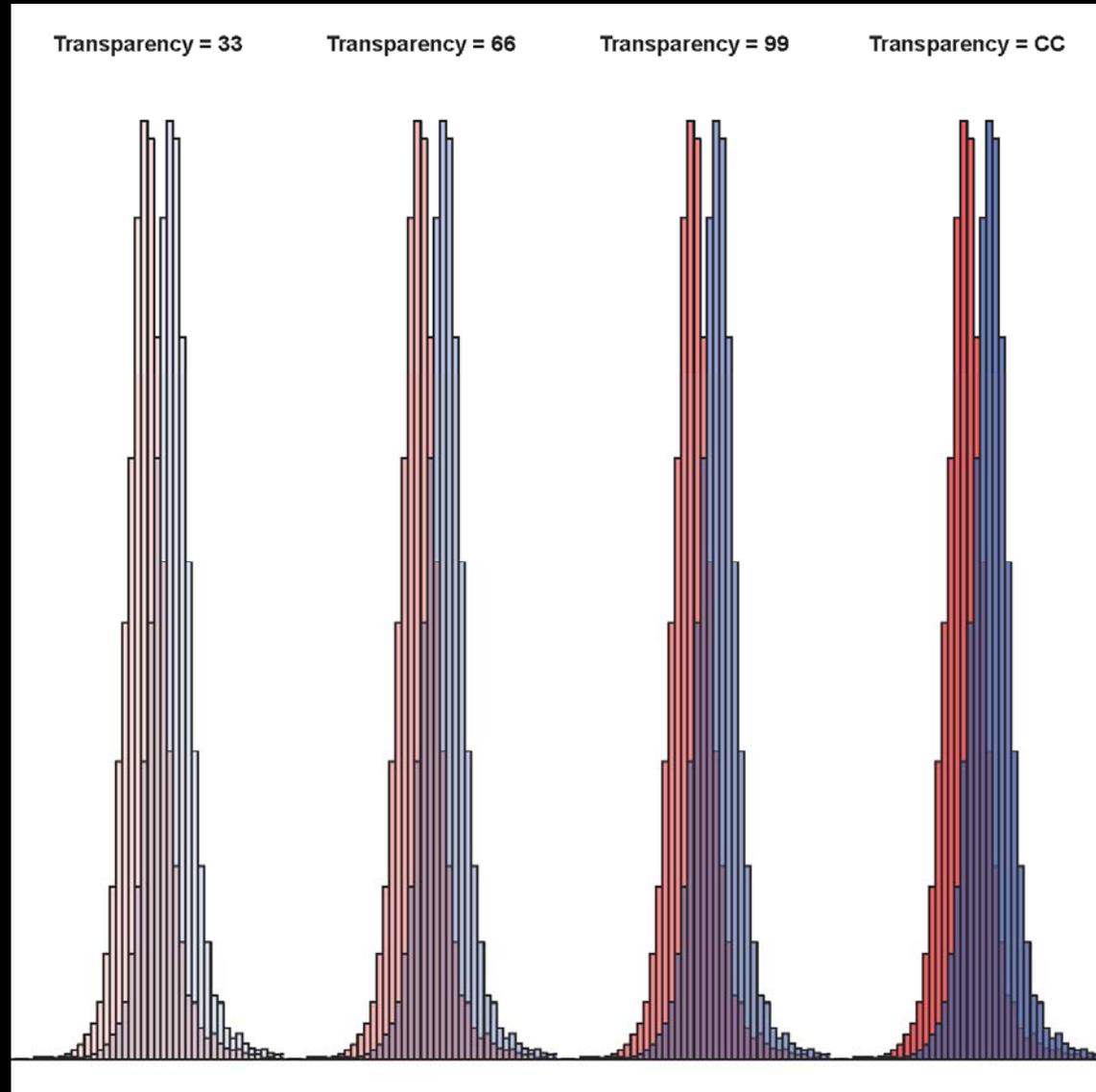
- Add line(s) with
abline(lmfit)



Transparent colors

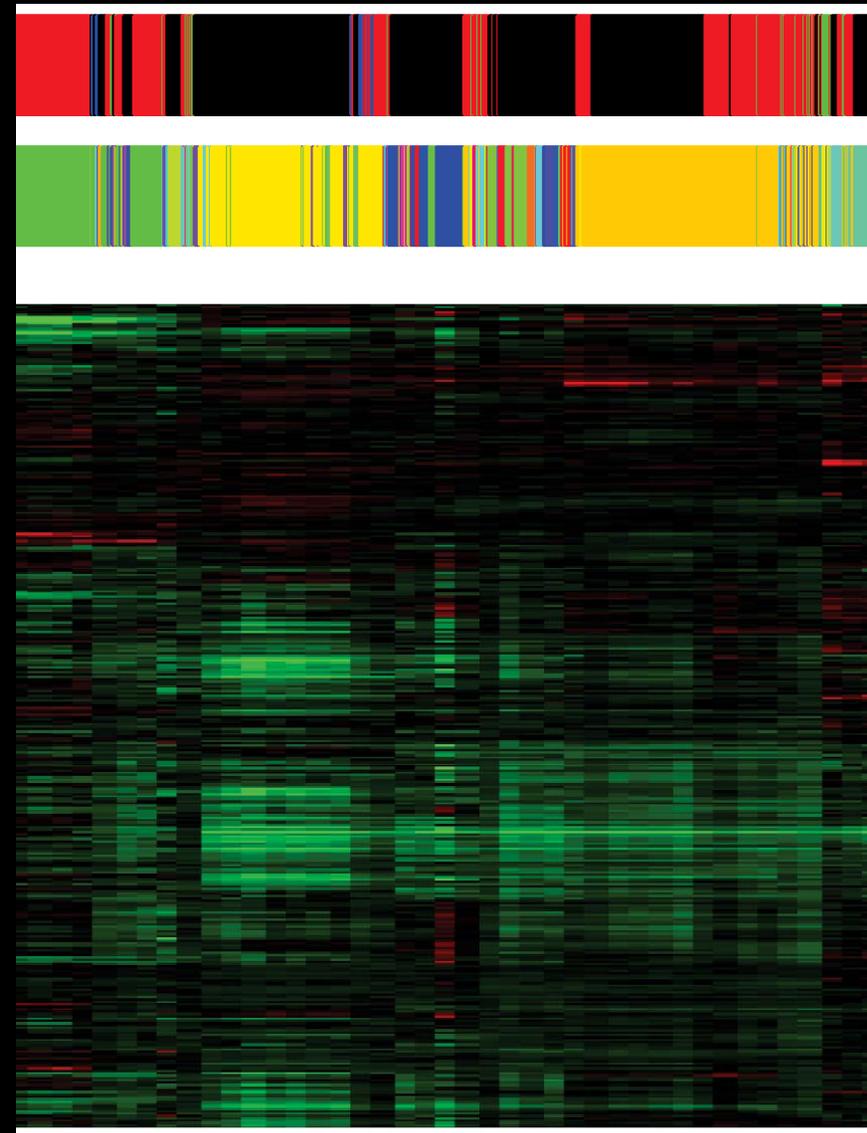
- Semitransparent colors can be indicated by an extended RGB code (#RRGGBBAA)
 - AA = opacity from 0-9,A-F (lowest to highest)
 - Sample colors:

Red	#FF000066
Green	#00FF0066
Blue	#0000FF66



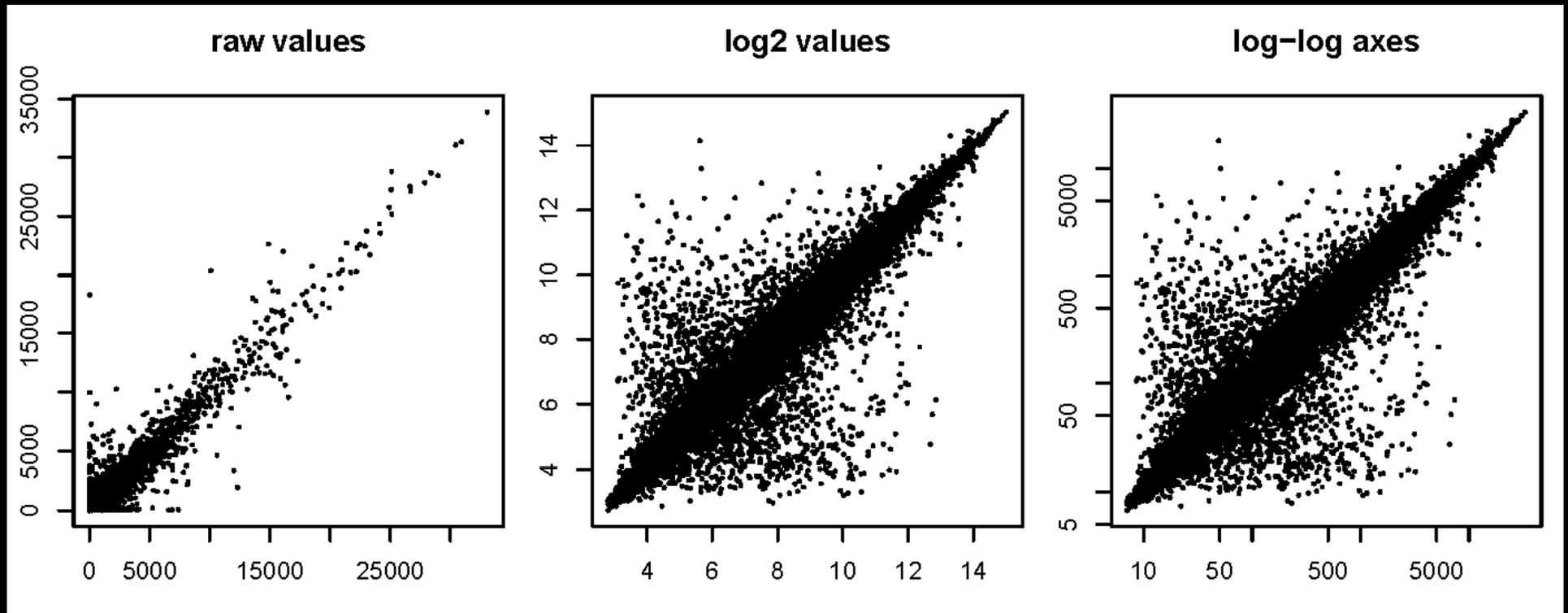
Colored bars

- Colored bars can be used to label rows or columns of a matrix
 - Ex: cell types, GO terms
- Limit each color code to 6-8 colors
- Don't forget the legend!



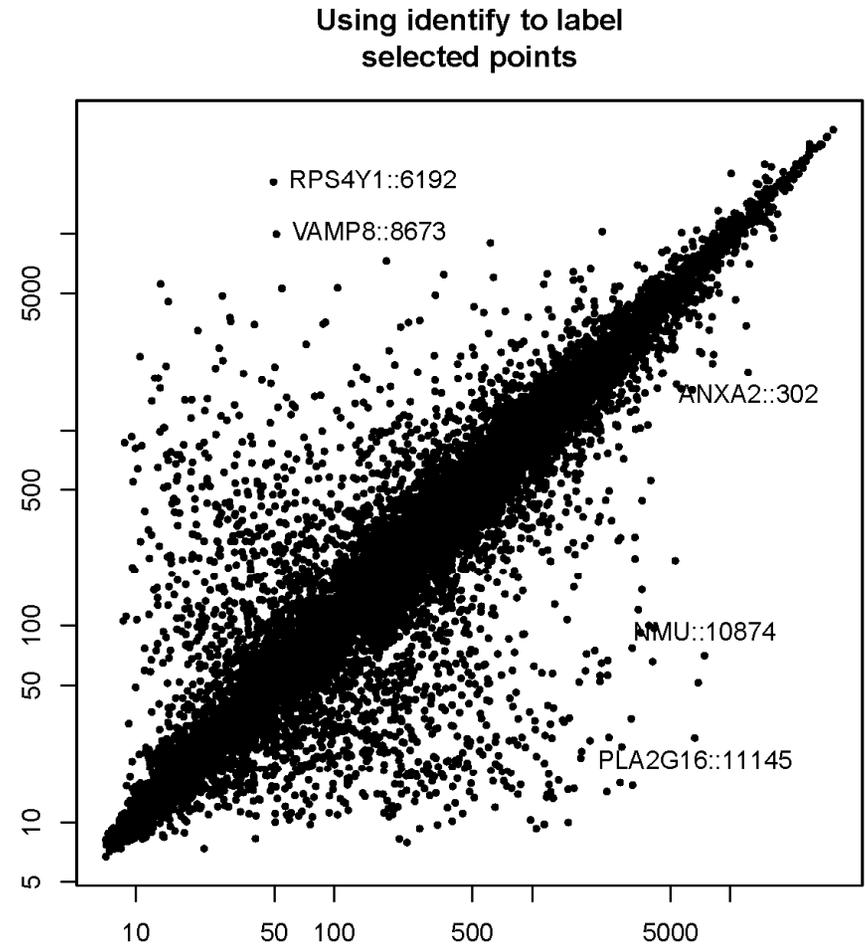
Handling log transformations

- Data or axes can be transformed or scaled.
- Which (if either) should be used?



Labeling selected points

1. Make figure
2. Run “identify” command
 - `identify(x, y, labels)`
 - **Ex:** `identify(genes, labels = rownames(genes))`
3. Click at or near points to label them
4. Save image



	WT cells	KO cells
MUC5B::727897	31.7	41.7
HAPLN4::404037	37.3	47.7
SIGLEC16::400709	24.1	32.7



More resources

- R Graph Gallery:
 - <http://addictedtor.free.fr/graphiques/>
- R scripts for Bioinformatics
 - <http://iona.wi.mit.edu/bio/bioinfo/Rscripts/>
- List of R modules installed on tak
 - <http://tak/trac/wiki/R>
- Our favorite book:
 - Introductory Statistics with R
(Peter Dalgard)
- We're glad to share commands and/or scripts to get you started



Upcoming Hot Topics

- Introduction to Bioconductor - microarray and RNA-Seq analysis (Thursday)
- Unix, Perl, and Perl modules (short course)
- Quality control for high-throughput data
- RNA-Seq analysis
- Gene list enrichment analysis
- Galaxy
- Sequence alignment: pairwise and multiple
- See http://iona.wi.mit.edu/bio/hot_topics/
- Other ideas? Let us know.

