Lecture 9

Brad McNeney

2018-03-15

Load packages

```r
library(ggplot2)
data(diamonds)
library(dplyr)
library(gapminder)
data(gapminder)
gapminder <- mutate(gapminder,
                    log10Pop = log10(pop),
                    log10GdpPercap = log10(gdpPercap))
```

References

- ggplot2 cheatsheet at [https://www.rstudio.com/wp-content/uploads/2016/11/ggplot2-cheatsheet-2.1.pdf]
- Wickham (2009) ggplot2: Elegant graphics for data analysis, Chapters 4 and 5.
- Chang (2012) R graphics cookbook. Available at [http://www.cookbook-r.com/Graphs/]

More details on `ggplot2`

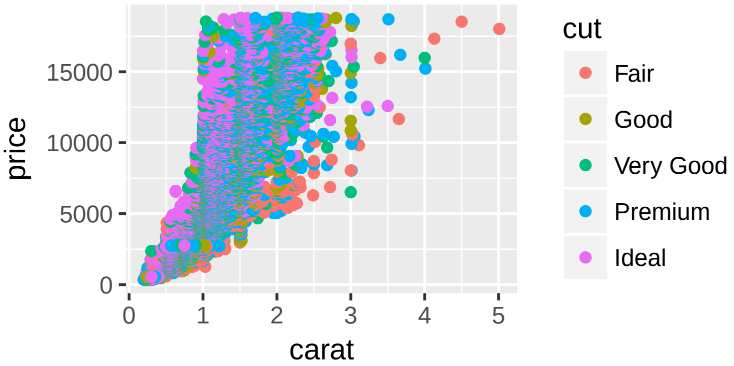
- **Layers**
  - data, aesthetic mapping, geom, statistical transformation and position adjustment (to be defined)
- Tools for working with layers
- Scales, axes and legends
- Faceting

Basic plot for demonstrations

```r
p <- ggplot(diamonds,aes(x=carat,y=price,colour=cut)) +
  geom_point()
names(p)
```

```
## [1] "data"        "layers"      "scales"      "mapping"     "theme"
## [6] "coordinates" "facet"       "plot_env"    "labels"
```

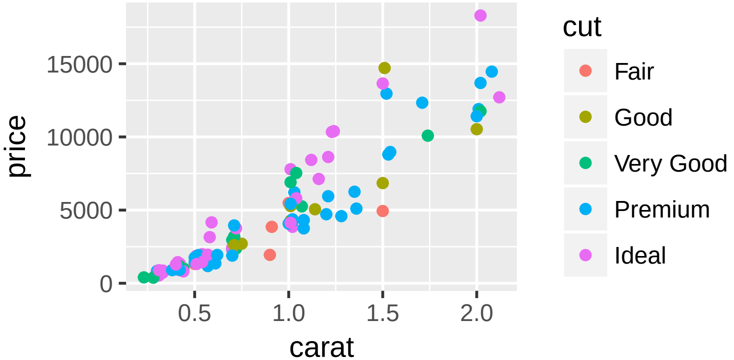
```r
p
```



Data

- The data must be a data frame
- A **copy** of the data is stored in the plot object (changes to the source dataframe do not change plot)
- Possible to change the data of a plot object with %+%, as in

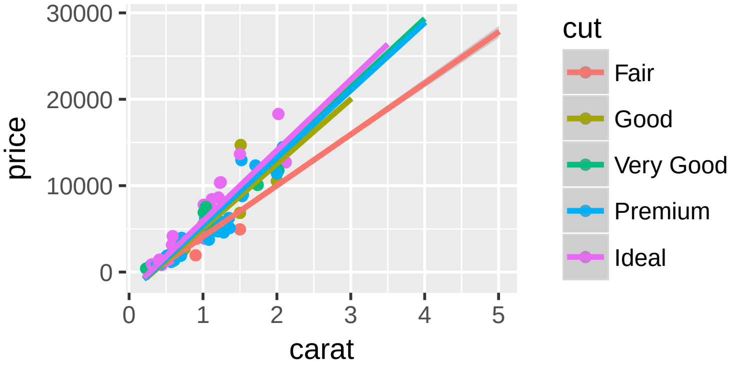
```
set.seed(123)
subdiamonds <- sample_n(diamonds,size=100)
p <- p %+% subdiamonds
p
```



Different data in different layers

- Can specify data for a layer to use.

```
p + geom_smooth(data=diamonds, method="lm")
```



Aesthetic mappings

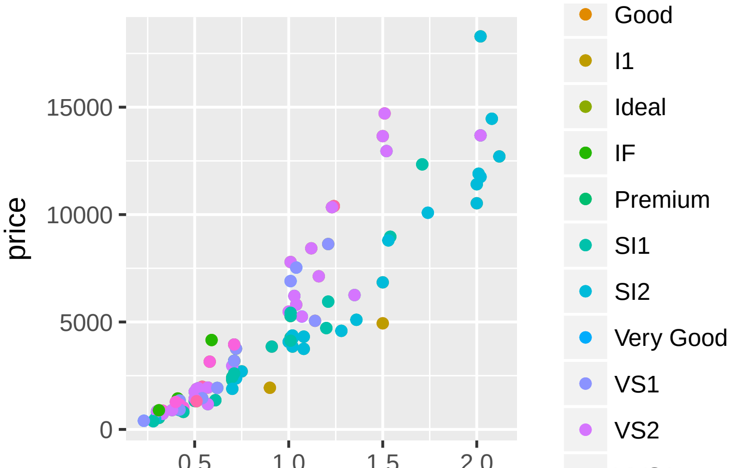
- A description of how variables will be perceived on a plot.
  - E.G., `aes(x=carat,y=price,color=cut)`
- Can specify default aesthetics in the initialization, or specific aesthetics in the layers
  - When specified in the layers they over-ride the defaults

```
p<-p + geom_point(aes(color=clarity))
```

Aesthetic over-ride

- Overriding affects only the layer, not the default scales
    - Unexpected behaviour: titles on legends and axes are taken from the default scale **and** layer; e.g., cut and clarity categories

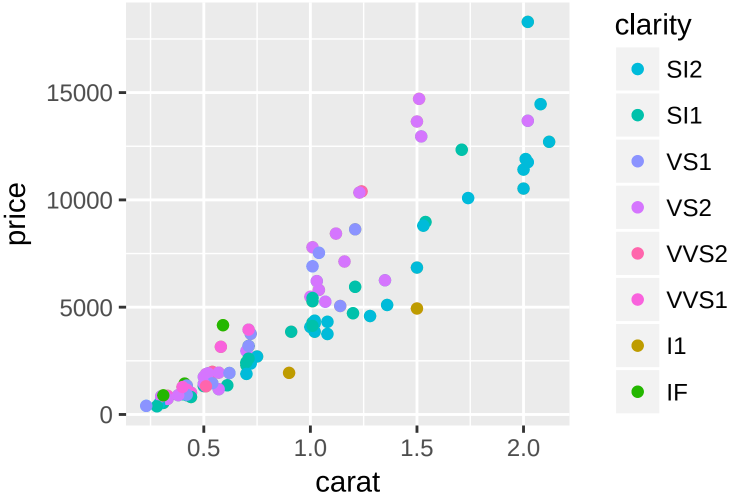
```
p
```



Aesthetic over-ride, cont.

- To modify the scale, set with a `scale` function (more later).

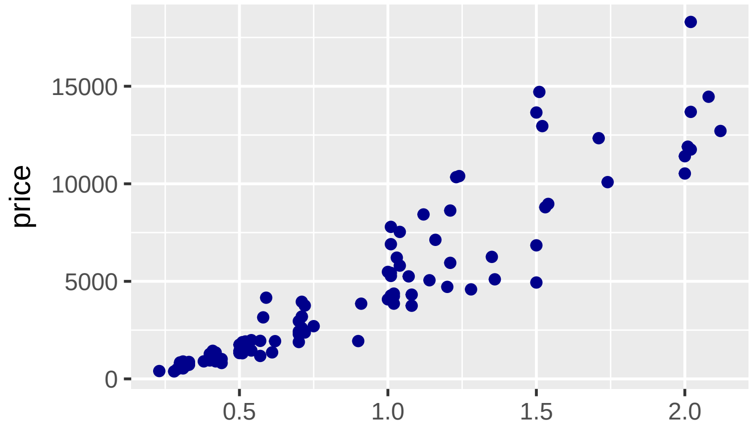
```
clarityscale <- c("SI2","SI1","VS1","VS2","VVS2","VVS1","I1","IF")
p + scale_color_discrete(name="clarity",breaks=clarityscale)
```



Setting vs mapping

- An alternative to mapping aesthetics to variables is to set the aesthetic to a constant.
  - Set with the layer *parameter*, rather than mapping with `aes()`
  - E.G., set the color of points on a plot to dark blue

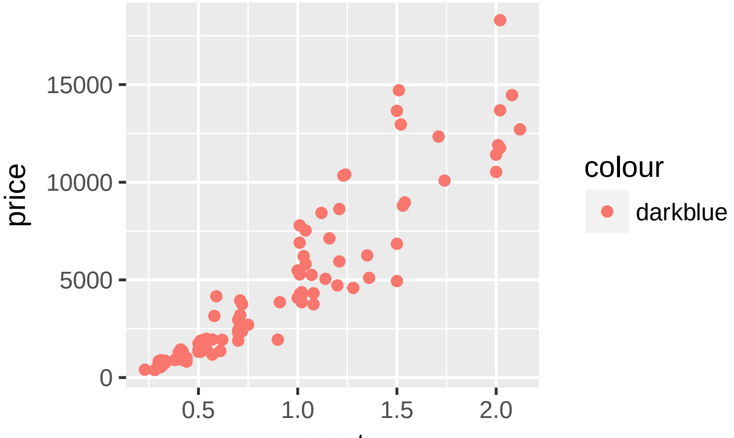
```
ggplot(subdiamonds,aes(x=carat,y=price)) + geom_point(color="darkblue")
```



Setting vs mapping, cont.

- Don't use `aes()` if you want a paramter.
  - e.g., `aes(color="darkblue")` creates a variable whose only value is "darkblue"

```
ggplot(subdiamonds,aes(x=carat,y=price)) +
 geom_point(aes(color="darkblue"))
```



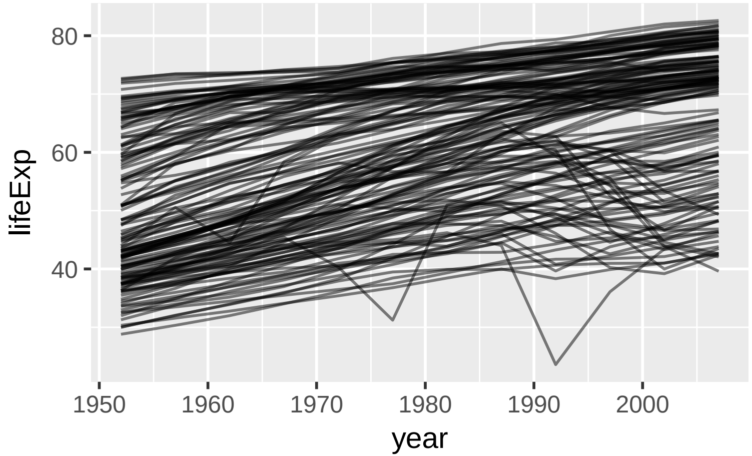
Grouping

- Many `geoms` in ggplot2 group observations (rows of the dataframe).
    - E.G., a boxplot of a quantitative variable by a categorical variable groups observations by the categorical variable.
- Default `group` is combinations (interaction) of all categorical variables in the aesthetic specification.
- If this is not what you want, or if there are no categorical variables, specify `group` yourself.

Grouping to plot time series

- For plotting time series (multiple measurements on each observational unit) we want to group by observational unit.

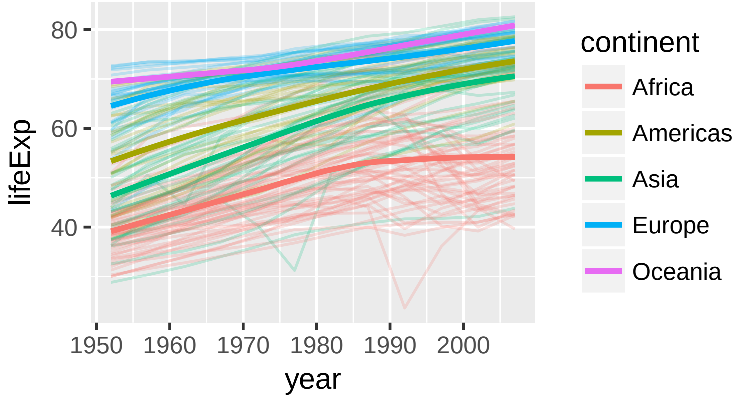
```
ggplot(gapminder,aes(x=year,y=lifeExp,group=country)) + geom_line(alpha=.5)
```



Different groups on different layers

- To add summaries by continent, we need to specify different groups on different layers.

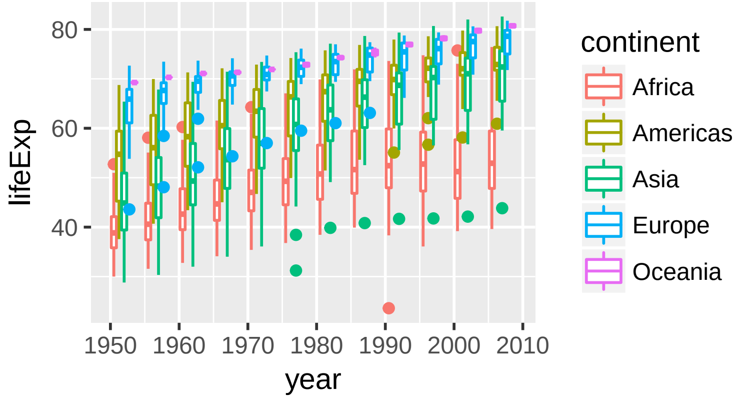
```
ggplot(gapminder,aes(x=year,y=lifeExp,group=country,
                     color=continent)) + geom_line(alpha=0.2) +
  geom_smooth(aes(group=continent),se=FALSE)
```



Using `interaction()` to specify groups

- Could do boxplots of life expectancy by year **and** continent. (Not recommended – too busy – just using for illustration.)

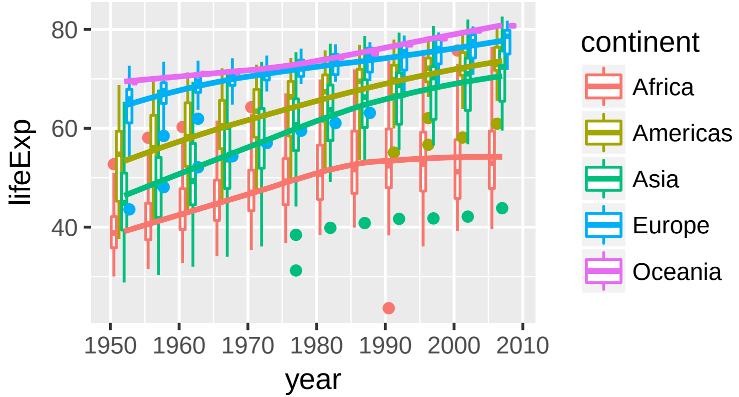
```
ggplot(gapminder,aes(x=year,y=lifeExp,
         group=interaction(year,continent),color=continent)) +
 geom_boxplot()
```



Overriding group on a layer

- Boxplots of life expectancy by year and continent on one layer, by continent alone on another.

```
ggplot(gapminder,aes(x=year,y=lifeExp, group=interaction(year,continent),
                     color=continent)) + geom_boxplot() +
  geom_smooth(aes(group=continent), se=FALSE)
```



Geoms

- These are the shapes you want on the plot.
  - See the list of geoms on the cheatsheet.
- Each has a set of aesthetics that are required for drawing and a set of aesthetics that it understands.
  - E.G., `geom_point()` requires x and y position, and understands color, size and shape.
- Aesthetics can also be passed to geoms as parameters.
  - Recall difference between `geom_point(color="darkblue")` and `geom_point(aes(color="darkblue"))`
- Each geom also has a default statistic (stat) and positional adjustment.
  - More on these next.

Stats

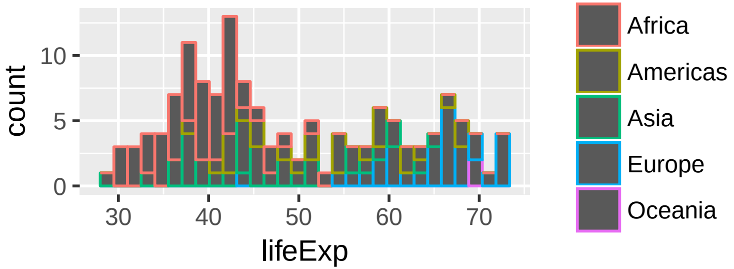
- Stats are statistical summaries of groups of data points. E.G.,
  - `stat_smoother()` is a moving average of the y positions over windows of x positions.
  - `stat_bin()` is a binning of a quantitative variable into bins of a given width
  - See the cheatsheet for a list.
- Stats create new variables, and these variables can be mapped to aesthetics.
  - E.G., `stat_bin()` creates the variables `count`, `density` and `x`
  - Enclose derived variable name with `..` to use.

```r
p <- ggplot(gapminder,aes(x=lifeExp)) +
  geom_histogram(aes(y= ..density..))
```

Position adjustment

- See cheatsheet for list.
- Default for most geoms is no adjustment ("identity")
- Adjustment to x and/or y position, such as "jitter" can reduce overplotting.
- Boxplots in recent plot of gapminder data were "dodge"d.
- Histograms of a continuous variable by a categorical grouping variable are "stack"ed by default.

```r
gdat <- filter(gapminder,year==1952)
ggplot(gdat,aes(x=lifeExp,color=continent)) + geom_histogram()
```



More details on `ggplot2`

- Layers
- **Tools for working with layers**
- Scales, axes and legends
- Faceting

Tools for working with layers

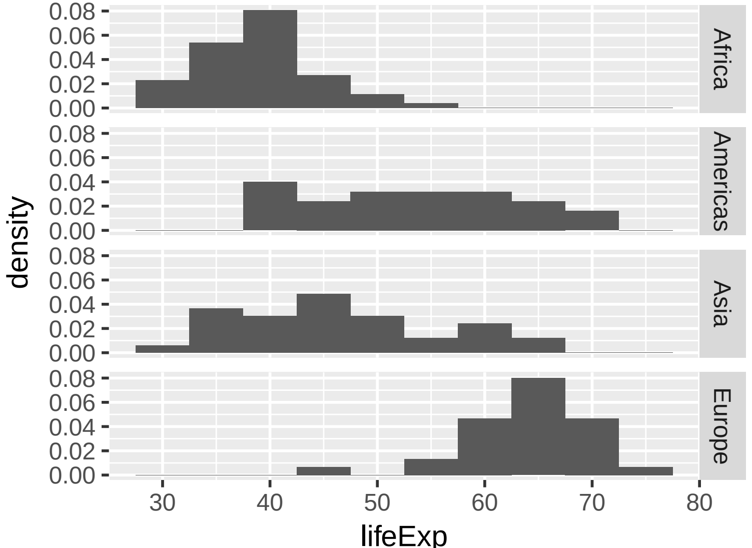
- Many possible topics
- In the interest of time, focus on a few
  - displaying distributions
  - adding error bars and other measures of uncertainty
  - annotating a plot

Displaying distributions

- The standard histogram is `geom_histogram()`.
  - Displays counts by default, but we have seen how to display as density
  - Density is better for comparing the shape of distributions
- To include group information, can stack bars (see previous example), use faceting to produce separate histograms, or superpose density histograms.

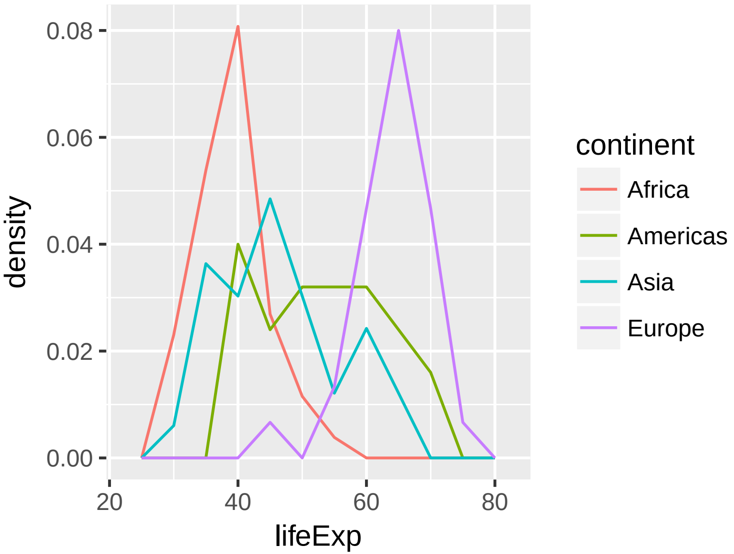
Histograms with faceting

```r
gdat <- filter(gdat,continent != "Oceania")
h <- ggplot(gdat,aes(x=lifeExp))
h + geom_histogram(aes(y= ..density..), binwidth=5) + facet_grid(continent ~ .)
```



Histograms superposed

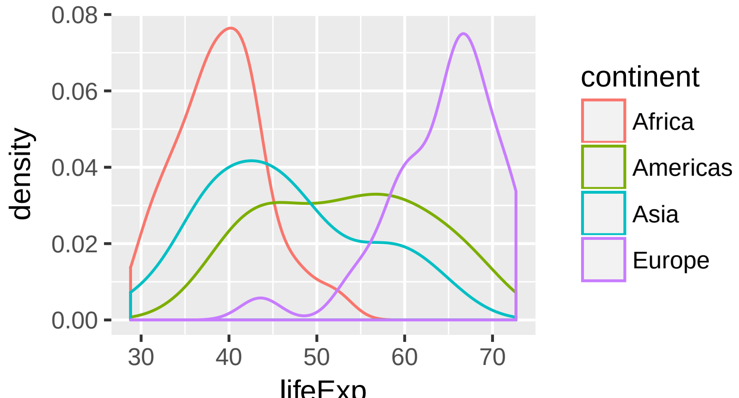
```r
h + geom_freqpoly(aes(y=..density..,color=continent), binwidth=5)
```



Density estimation

- `geom_density()` plots a density estimate
  - Think of adding up small normal densities centred at each observed datapoint, with the width of each distribution a user-defined parameter
- Can superpose multiple density plots.

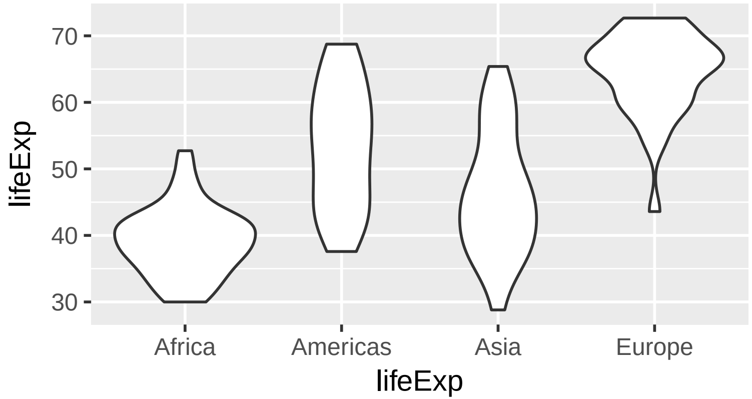
```r
h + geom_density(aes(color=continent))
```



Violin plots

- Instead of superposing, dodge density estimates with a violin plot.
  - Violins are density estimate and its mirror image displayed vertically

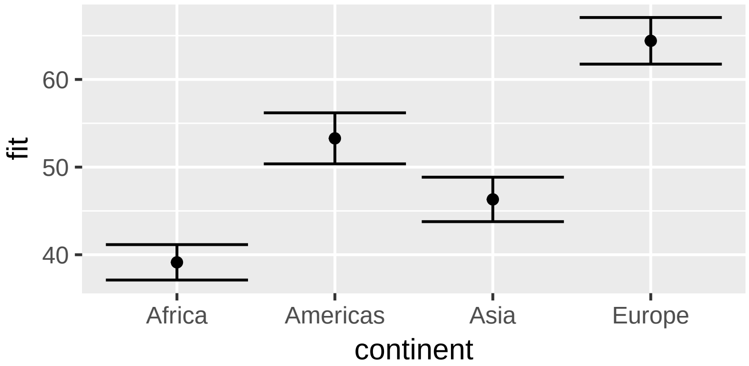
```
h + geom_violin(aes(x=continent,y=lifeExp))
```



Adding measures of uncertainty

- `geom_smooth()` includes pointwise error bands by default.
- For factors can add error bars.

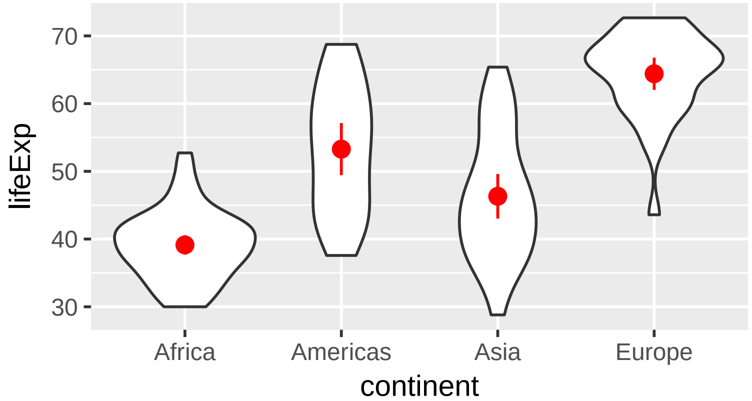
```
gfit <- lm(lifeExp ~ continent,data=gdat)
newdat <- data.frame(continent=c("Africa","Americas","Asia","Europe"))
mm <- data.frame(newdat,predict(gfit,newdata=newdat,interval="confidence"))
ggplot(mm,aes(x=continent,y=fit)) +
  geom_point() +  geom_errorbar(aes(ymin=lwr,ymax=upr))
```



Measures of uncertainty with stat summaries

- Variety of built-in summaries, or can write your own (not covered).
- Summarize y for different values of x or bins of x values.

```
ggplot(gdat,aes(x=continent,y=lifeExp)) +
 geom_violin() + # superpose over violin plot
 stat_summary(fun.data="mean_cl_normal",color="red")
```

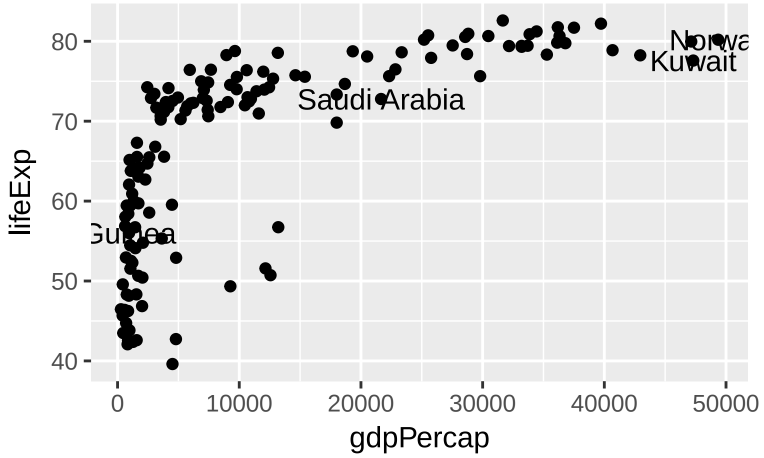


Annotating a plot

- Basic tools for annotating are
    - `geom_text()` and `geom_label()` to add text
    - Geoms such as `geom_abline()` to add line segments (see cheetsheet)
    - `labs()` for adding axis labels, titles, and captions
    - `annotate()` to add annotations using aesthetics passed as vectors to the function, rather than mapped from a dataframe.
- Can add annotations one at a time or many at a time
    - to add many at a time, create a data frame

Many annotations

```r
gm07 <- filter(gapminder, year ==2007)
topOilbyGDP <- c("Kuwait","Guinea","Norway","Saudi Arabia")
gdpOil <- filter(gm07,country %in% topOilbyGDP)
ggplot(gm07,aes(x=gdpPercap,y=lifeExp)) + geom_point() +
  geom_text(data=gdpOil,aes(label=country))
```



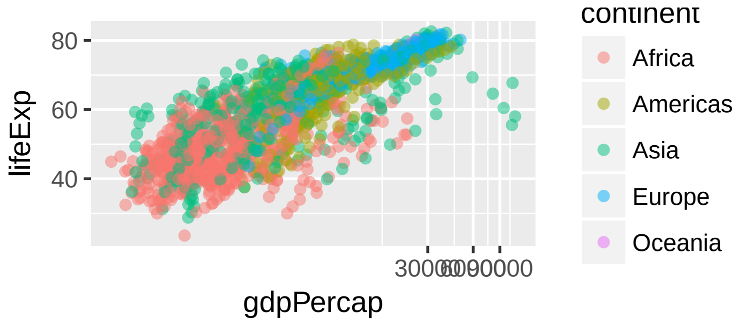
More details on `ggplot2`

- Layers
- Tools
- **Scales, axes and legends**
- Faceting

Scales

- Scales are mappings from the data to the graphics device
  - domain of `continent` is the five continents, range is the hexidecimal of the five colors represented on the graph
  - domain of `lifeExp` is 23.599 to 82.603, range is [0,1], which `grid` converts to a range of vertical pixels on the graph.
  - legends and axes provide the inverse mapping

```
p <- ggplot(gapminder,aes(x=gdpPercap,y=lifeExp,color=continent)) +
  geom_point(alpha=0.5) + coord_trans(x="log10")
p
```



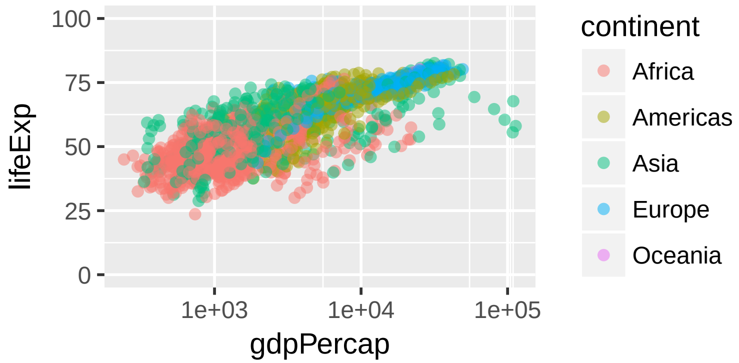
Steps to map domain to range

- Transformation: For continuous domains, we may want a transformation of the data
  - E.G., log base 10 of GDP, specified by `coord_trans(x="log10")`
- Training: If multiple layers will be plotted, take the union of the domains of each
  - Can over-ride training and specify manually (next slide)
- Mapping: Apply the scaling function to map data values to what we see.

Axis labels and limits

- `breaks` are the locations of the tick marks on the axes
- `limits` are the limits of the axes

```
p + scale_x_continuous(breaks=c(1000,10000,100000)) +
 scale_y_continuous(limits = c(0,100))
```



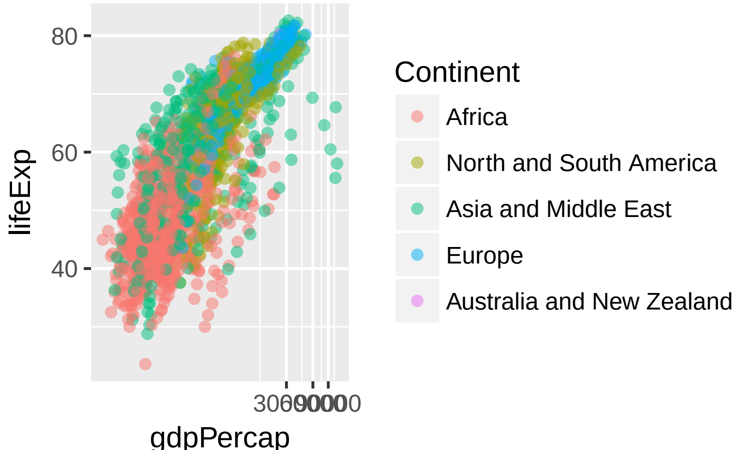
Types of scales

- In the previous example we saw position scales that control x and y positions of objects
- Other scales control colour and fill, shape, line type and size.
    - See the cheetsheet for a list

Color scale settings and legends

- For discrete variables used to set the colour aesthetic, colour scale settings affect the legend labels and titles

```
p + scale_color_discrete(name="Continent",
  labels=c("Africa","North and South America",
           "Asia and Middle East","Europe","Australia and New Zealand"))
```



More details on `ggplot2`

- Layers
- Tools
- Scales
- **Faceting**

Faceting

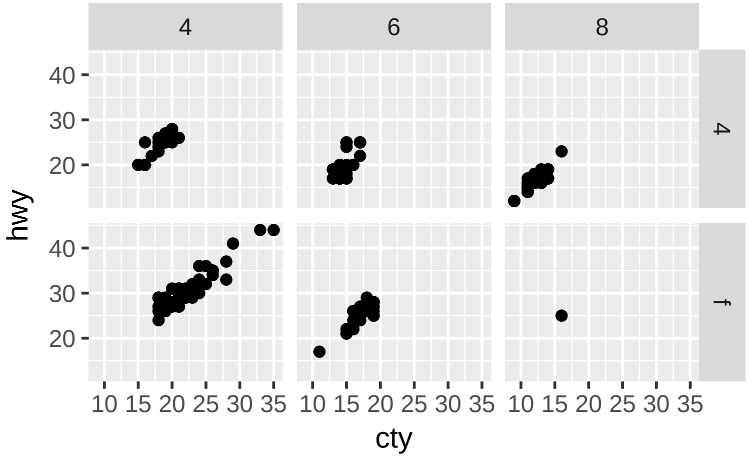
- Facets are panels that show plots for subsets of the data defined by groups.
- Layout of facets can be as a grid or a ribbon.
- Use a subset of the `mpg` dataset from `ggplot2` to illustrate

```r
data(mpg)
mpgsub <- subset(mpg,cyl !=5 & drv %in% c("4","f"))
```

Facet grid

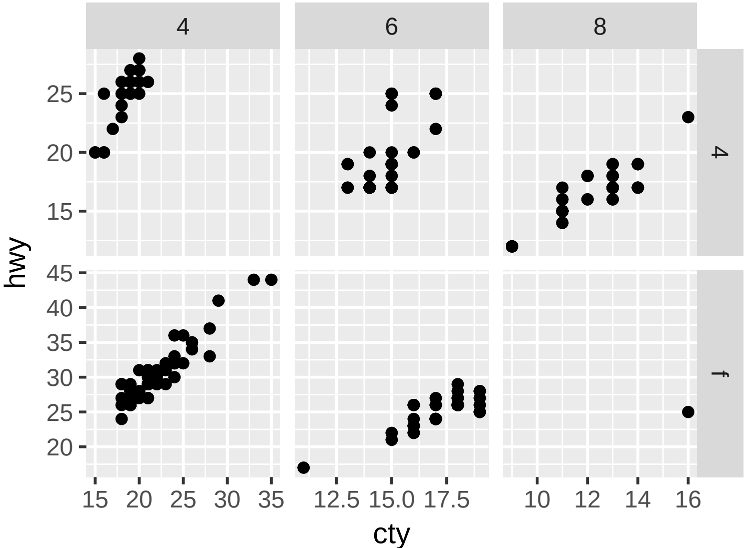
- Lay out plots in a 2d grid, specified by a formula.

```
p <- ggplot(mpgsub,aes(x=cty,y=hwy)) +
  geom_point() + facet_grid(drv~ cyl)
p
```



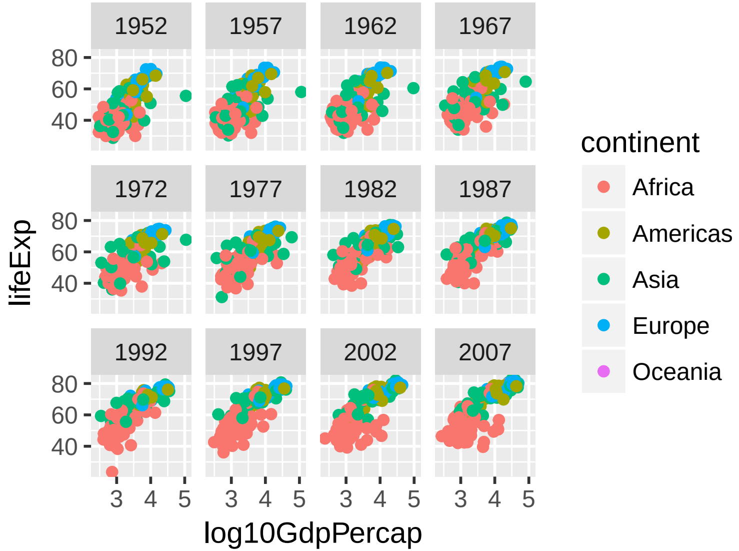
Freeing the scales across rows/columns of panels

```r
p <- ggplot(mpgsub,aes(x=cty,y=hwy)) +
  geom_point() + facet_grid(drv~ cyl, scales="free")
p
```



Facet wrap

```
ggplot(gapminder,aes(x=log10GdpPercap,y=lifeExp,color=continent)) +
  geom_point() + facet_wrap(~year,ncol=4)
```


lifeExp
log10GdpPercap
continent
Africa
Americas
Asia
Europe
Oceania