

# Data Visualization with ggplot2 : : CHEAT SHEET

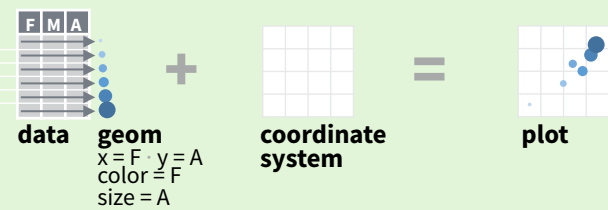


## Basics

ggplot2 is based on the **grammar of graphics**, the idea that you can build every graph from the same components: a **data** set, a **coordinate system**, and **geoms**—visual marks that represent data points.



To display values, map variables in the data to visual properties of the geom (**aesthetics**) like **size**, **color**, and **x** and **y** locations.



Complete the template below to build a graph.

```
ggplot (data = <DATA>) +
  <GEOM_FUNCTION> (mapping = aes(<MAPPINGS>),
  stat = <STAT>, position = <POSITION>) +
  <COORDINATE_FUNCTION> +
  <FACET_FUNCTION> +
  <SCALE_FUNCTION> +
  <THEME_FUNCTION>
```

**required**

**Not required, sensible defaults supplied**

**ggplot**(data = mpg, aes(x = cty, y = hwy)) Begins a plot that you finish by adding layers to. Add one geom function per layer.

aesthetic mappings   data   geom

**qplot**(x = cty, y = hwy, data = mpg, geom = "point") Creates a complete plot with given data, geom, and mappings. Supplies many useful defaults.

**last\_plot()** Returns the last plot

**ggsave**("plot.png", width = 5, height = 5) Saves last plot as 5' x 5' file named "plot.png" in working directory. Matches file type to file extension.

## Geoms

Use a geom function to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

### GRAPHICAL PRIMITIVES

a <- ggplot(economics, aes(date, unemployment))  
b <- ggplot(seals, aes(x = long, y = lat))

- a + geom\_blank()**  
(Useful for expanding limits)
- b + geom\_curve**(aes(yend = lat + 1, xend = long + 1, curvature = z)) - x, xend, y, yend, alpha, angle, color, curvature, linetype, size
- a + geom\_path**(lineend = "butt", linejoin = "round", linemitre = 1) - x, y, alpha, color, group, linetype, size
- a + geom\_polygon**(aes(group = group)) - x, y, alpha, color, fill, group, linetype, size
- b + geom\_rect**(aes(xmin = long, ymin = lat, xmax = long + 1, ymax = lat + 1)) - xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size
- a + geom\_ribbon**(aes(ymin = unemployment - 900, ymax = unemployment + 900)) - x, ymax, ymin, alpha, color, fill, group, linetype, size

### LINE SEGMENTS

common aesthetics: x, y, alpha, color, linetype, size

- b + geom\_abline**(aes(intercept = 0, slope = 1))
- b + geom\_hline**(aes(yintercept = lat))
- b + geom\_vline**(aes(xintercept = long))
- b + geom\_segment**(aes(yend = lat + 1, xend = long + 1))
- b + geom\_spoke**(aes(angle = 1:1155, radius = 1))

### ONE VARIABLE continuous

- c <- ggplot(mpg, aes(hwy)); c2 <- ggplot(mpg)
- c + geom\_area**(stat = "bin") - x, y, alpha, color, fill, linetype, size
- c + geom\_density**(kernel = "gaussian") - x, y, alpha, color, fill, group, linetype, size, weight
- c + geom\_dotplot**() - x, y, alpha, color, fill
- c + geom\_freqpoly**() - x, y, alpha, color, group, linetype, size
- c + geom\_histogram**(binwidth = 5) - x, y, alpha, color, fill, linetype, size, weight
- c2 + geom\_qq**(aes(sample = hwy)) - x, y, alpha, color, fill, linetype, size, weight

### discrete

- d <- ggplot(mpg, aes(fl))
- d + geom\_bar**() - x, alpha, color, fill, linetype, size, weight

### TWO VARIABLES

#### continuous x, continuous y

- e <- ggplot(mpg, aes(cty, hwy))
- e + geom\_label**(aes(label = cty), nudge\_x = 1, nudge\_y = 1, check\_overlap = TRUE) - x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust
- e + geom\_jitter**(height = 2, width = 2) - x, y, alpha, color, fill, shape, size
- e + geom\_point**() - x, y, alpha, color, fill, shape, size, stroke
- e + geom\_quantile**() - x, y, alpha, color, group, linetype, size, weight
- e + geom\_rug**(sides = "bl") - x, y, alpha, color, linetype, size
- e + geom\_smooth**(method = lm) - x, y, alpha, color, fill, group, linetype, size, weight
- e + geom\_text**(aes(label = cty), nudge\_x = 1, nudge\_y = 1, check\_overlap = TRUE) - x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

#### discrete x, continuous y

- f <- ggplot(mpg, aes(class, hwy))
- f + geom\_col**() - x, y, alpha, color, fill, group, linetype, size
- f + geom\_boxplot**() - x, y, lower, middle, upper, ymax, ymin, alpha, color, fill, group, linetype, shape, size, weight
- f + geom\_dotplot**(binaxis = "y", stackdir = "center") - x, y, alpha, color, fill, group
- f + geom\_violin**(scale = "area") - x, y, alpha, color, fill, group, linetype, size, weight

#### discrete x, discrete y

- g <- ggplot(diamonds, aes(cut, color))
- g + geom\_count**() - x, y, alpha, color, fill, shape, size, stroke

### THREE VARIABLES

- seals\$z <- with(seals, sqrt(delta\_long^2 + delta\_lat^2)); l <- ggplot(seals, aes(long, lat))
- l + geom\_contour**(aes(z = z)) - x, y, z, alpha, colour, group, linetype, size, weight
- l + geom\_raster**(aes(fill = z), hjust = 0.5, vjust = 0.5, interpolate = FALSE) - x, y, alpha, fill
- l + geom\_tile**(aes(fill = z), x, y, alpha, color, fill, linetype, size, width)

### continuous bivariate distribution

- h <- ggplot(diamonds, aes(carat, price))
- h + geom\_bin2d**(binwidth = c(0.25, 500)) - x, y, alpha, color, fill, linetype, size, weight
- h + geom\_density2d**() - x, y, alpha, colour, group, linetype, size
- h + geom\_hex**() - x, y, alpha, colour, fill, size

### continuous function

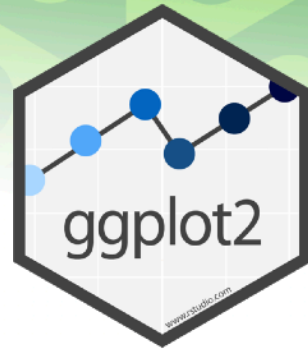
- i <- ggplot(economics, aes(date, unemployment))
- i + geom\_area**() - x, y, alpha, color, fill, linetype, size
- i + geom\_line**() - x, y, alpha, color, group, linetype, size
- i + geom\_step**(direction = "hv") - x, y, alpha, color, group, linetype, size

### visualizing error

- df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)
- j <- ggplot(df, aes(grp, fit, ymin = fit - se, ymax = fit + se))
- j + geom\_crossbar**(fatten = 2) - x, y, ymax, ymin, alpha, color, fill, group, linetype, size
- j + geom\_errorbar**() - x, ymax, ymin, alpha, color, group, linetype, size, width (also **geom\_errorbarh**())
- j + geom\_linerange**() - x, ymin, ymax, alpha, color, group, linetype, size
- j + geom\_pointrange**() - x, y, ymin, ymax, alpha, color, fill, group, linetype, shape, size

### maps

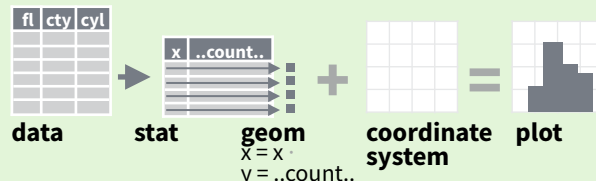
- data <- data.frame(murder = USArrests\$Murder, state = tolower(rownames(USArrests)))
- map <- map\_data("state")
- k <- ggplot(data, aes(fill = murder))
- k + geom\_map**(aes(map\_id = state), map = map) + **expand\_limits**(x = map\$long, y = map\$lat), map\_id, alpha, color, fill, linetype, size



# Stats

An alternative way to build a layer

A stat builds new variables to plot (e.g., count, prop).



Visualize a stat by changing the default stat of a geom function, `geom_bar(stat="count")` or by using a stat function, `stat_count(geom="bar")`, which calls a default geom to make a layer (equivalent to a geom function). Use `..name..` syntax to map stat variables to aesthetics.

**geom to use** **stat function** **geom mappings**

```
i + stat_density2d(aes(fill = ..level..),
  geom = "polygon")
```

**variable created by stat**

- `c + stat_bin(binwidth = 1, origin = 10)`  
`x, y | ..count.., ..ncount.., ..density.., ..ndensity..`
- `c + stat_count(width = 1)` `x, y, | ..count.., ..prop..`
- `c + stat_density(adjust = 1, kernel = "gaussian")`  
`x, y, | ..count.., ..density.., ..scaled..`
- `e + stat_bin_2d(bins = 30, drop = T)`  
`x, y, fill | ..count.., ..density..`
- `e + stat_bin_hex(bins=30) x, y, fill | ..count.., ..density..`
- `e + stat_density_2d(contour = TRUE, n = 100)`  
`x, y, color, size | ..level..`
- `e + stat_ellipse(level = 0.95, segments = 51, type = "t")`
- `l + stat_contour(aes(z = z)) x, y, z, order | ..level..`
- `l + stat_summary_hex(aes(z = z), bins = 30, fun = max)`  
`x, y, z, fill | ..value..`
- `l + stat_summary_2d(aes(z = z), bins = 30, fun = mean)`  
`x, y, z, fill | ..value..`
- `f + stat_boxplot(coef = 1.5) x, y | ..lower.., ..middle.., ..upper.., ..width.., ..ymin.., ..ymax..`
- `f + stat_ydensity(kernel = "gaussian", scale = "area") x, y | ..density.., ..scaled.., ..count.., ..n.., ..violinwidth.., ..width..`
- `e + stat_ecdf(n = 40) x, y | ..x.., ..y..`
- `e + stat_quantile(quantiles = c(0.1, 0.9), formula = y ~ log(x), method = "rq") x, y | ..quantile..`
- `e + stat_smooth(method = "lm", formula = y ~ x, se=T, level=0.95) x, y | ..se.., ..x.., ..y.., ..ymin.., ..ymax..`
- `ggplot() + stat_function(aes(x = -3:3), n = 99, fun = dnorm, args = list(sd=0.5)) x | ..x.., ..y..`
- `e + stat_identity(na.rm = TRUE)`
- `ggplot() + stat_qq(aes(sample=1:100), dist = qt, dparam=list(df=5)) sample, x, y | ..sample.., ..theoretical..`
- `e + stat_sum() x, y, size | ..n.., ..prop..`
- `e + stat_summary(fun.data = "mean_cl_boot")`
- `h + stat_summary_bin(fun.y = "mean", geom = "bar")`
- `e + stat_unique()`

# Scales

Scales map data values to the visual values of an aesthetic. To change a mapping, add a new scale.

```
(n <- d + geom_bar(aes(fill = fl)))
```

**scale\_\*** aesthetic to adjust

```
n + scale_fill_manual(values = c("skyblue", "royalblue", "blue", "navy"),
  limits = c("d", "e", "p", "r"), breaks = c("d", "e", "p", "r"),
  name = "fuel", labels = c("D", "E", "P", "R"))
```

**range of values to include in mapping** **title to use in legend/axis** **labels to use in legend/axis** **breaks to use in legend/axis**

## GENERAL PURPOSE SCALES

- Use with most aesthetics
- `scale_*_continuous()` - map cont' values to visual ones
- `scale_*_discrete()` - map discrete values to visual ones
- `scale_*_identity()` - use data values as visual ones
- `scale_*_manual(values = c())` - map discrete values to manually chosen visual ones
- `scale_*_date(date_labels = "%m/%d")`, `date_breaks = "2 weeks"` - treat data values as dates.
- `scale_*_datetime()` - treat data x values as date times. Use same arguments as `scale_x_date()`. See `?strptime` for label formats.

## X & Y LOCATION SCALES

- Use with x or y aesthetics (x shown here)
- `scale_x_log10()` - Plot x on log10 scale
- `scale_x_reverse()` - Reverse direction of x axis
- `scale_x_sqrt()` - Plot x on square root scale

## COLOR AND FILL SCALES (DISCRETE)

```
n <- d + geom_bar(aes(fill = fl))
```

```
n + scale_fill_brewer(palette = "Blues")
```

For palette choices: `RColorBrewer::display.brewer.all()`

```
n + scale_fill_grey(start = 0.2, end = 0.8, na.value = "red")
```

## COLOR AND FILL SCALES (CONTINUOUS)

```
o <- c + geom_dotplot(aes(fill = ..x..))
```

```
o + scale_fill_distiller(palette = "Blues")
```

```
o + scale_fill_gradient(low="red", high="yellow")
```

```
o + scale_fill_gradient2(low="red", high="blue", mid="white", midpoint = 25)
```

```
o + scale_fill_gradientn(colours=topo.colors(6))
```

Also: `rainbow()`, `heat.colors()`, `terrain.colors()`, `cm.colors()`, `RColorBrewer::brewer.pal()`

## SHAPE AND SIZE SCALES

```
p <- e + geom_point(aes(shape = fl, size = cyl))
```

```
p + scale_shape() + scale_size()
```

```
p + scale_shape_manual(values = c(3:7))
```

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

```
p + scale_radius(range = c(1,6))
```

```
p + scale_size_area(max_size = 6)
```

# Coordinate Systems

```
r <- d + geom_bar()
```

```
r + coord_cartesian(xlim = c(0, 5))
```

`xlim, ylim`  
The default cartesian coordinate system

```
r + coord_fixed(ratio = 1/2)
```

`ratio, xlim, ylim`  
Cartesian coordinates with fixed aspect ratio between x and y units

```
r + coord_flip()
```

`xlim, ylim`  
Flipped Cartesian coordinates

```
r + coord_polar(theta = "x", direction=1)
```

`theta, start, direction`  
Polar coordinates

```
r + coord_trans(ytrans = "sqrt")
```

`xtrans, ytrans, limx, limy`  
Transformed cartesian coordinates. Set `xtrans` and `ytrans` to the name of a window function.

```
π + coord_quickmap()
```

```
π + coord_map(projection = "ortho", orientation=c(41, -74, 0))
```

`projection, orientzation, xlim, ylim`  
Map projections from the `mapproj` package (mercator (default), `azequalarea`, `lagrange`, etc.)

# Position Adjustments

Position adjustments determine how to arrange geoms that would otherwise occupy the same space.

```
s <- ggplot(mpg, aes(fl, fill = drv))
```

```
s + geom_bar(position = "dodge")
```

Arrange elements side by side

```
s + geom_bar(position = "fill")
```

Stack elements on top of one another, normalize height

```
e + geom_point(position = "jitter")
```

Add random noise to X and Y position of each element to avoid overplotting

```
e + geom_label(position = "nudge")
```

Nudge labels away from points

```
s + geom_bar(position = "stack")
```

Stack elements on top of one another

Each position adjustment can be recast as a function with manual `width` and `height` arguments

```
s + geom_bar(position = position_dodge(width = 1))
```

# Themes

```
r + theme_bw()
```

White background with grid lines

```
r + theme_classic()
```

```
r + theme_light()
```

```
r + theme_linedraw()
```

Minimal themes

```
r + theme_gray()
```

Grey background (default theme)

```
r + theme_minimal()
```

Empty theme

```
r + theme_dark()
```

dark for contrast

# Faceting

Facets divide a plot into subplots based on the values of one or more discrete variables.

```
t <- ggplot(mpg, aes(cty, hwy)) + geom_point()
```

```
t + facet_grid(cols = vars(fl))
```

facet into columns based on fl

```
t + facet_grid(rows = vars(year))
```

facet into rows based on year

```
t + facet_grid(rows = vars(year), cols = vars(fl))
```

facet into both rows and columns

```
t + facet_wrap(vars(fl))
```

wrap facets into a rectangular layout

Set `scales` to let axis limits vary across facets

```
t + facet_grid(rows = vars(drv), cols = vars(fl), scales = "free")
```

x and y axis limits adjust to individual facets

```
"free_x"
```

x axis limits adjust

```
"free_y"
```

y axis limits adjust

Set `labeller` to adjust facet labels

```
t + facet_grid(cols = vars(fl), labeller = label_both)
```

fl: c	fl: d	fl: e	fl: p	fl: r
$\alpha^c$	$\alpha^d$	$\alpha^e$	$\alpha^p$	$\alpha^r$

```
t + facet_grid(rows = vars(fl), labeller = label_bquote(alpha ^ .(fl)))
```

# Labels

```
t + labs(x = "New x axis label", y = "New y axis label", title = "Add a title above the plot", subtitle = "Add a subtitle below title", caption = "Add a caption below plot", <AES> = "New <AES> legend title")
```

Use scale functions to update legend labels

```
t + annotate(geom = "text", x = 8, y = 9, label = "A")
```

geom to place manual values for geom's aesthetics

# Legends

- `n + theme(legend.position = "bottom")`  
Place legend at "bottom", "top", "left", or "right"
- `n + guides(fill = "none")`  
Set legend type for each aesthetic: colorbar, legend, or none (no legend)
- `n + scale_fill_discrete(name = "Title", labels = c("A", "B", "C", "D", "E"))`  
Set legend title and labels with a scale function.

# Zooming

```
t + coord_cartesian(xlim = c(0, 100), ylim = c(10, 20))
```

Without clipping (preferred)

```
t + xlim(0, 100) + ylim(10, 20)
```

With clipping (removes unseen data points)

```
t + scale_x_continuous(limits = c(0, 100)) + scale_y_continuous(limits = c(10, 20))
```