

# Data Visualization with ggplot2 : : CHEAT SHEET

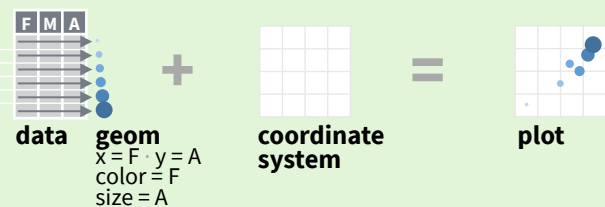


## Basics

**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.

**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, unemploy))  
b <- ggplot(seals, aes(x = long, y = lat))
```

- a + geom\_blank()** and **a + expand\_limits()**  
Ensure limits include values across all plots.
- b + geom\_curve**(aes(yend = lat + 1, xend = long + 1, curvature = 1) - x, 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(alpha = 50)) - x, y, alpha, color, fill, group, subgroup, 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 = unemploy - 900, ymax = unemploy + 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) - x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust
- 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) - 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
- e + geom\_jitter**(height = 2, width = 2) - x, y, alpha, color, fill, shape, size

### 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, color, group, linetype, size, weight
- l + geom\_contour\_filled**(aes(fill = z)) - x, y, alpha, color, fill, group, linetype, size, subgroup

#### 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\_density\_2d()** - x, y, alpha, color, group, linetype, size
- h + geom\_hex()** - x, y, alpha, color, fill, size

#### continuous function

```
i <- ggplot(economics, aes(date, unemploy))
```

- 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

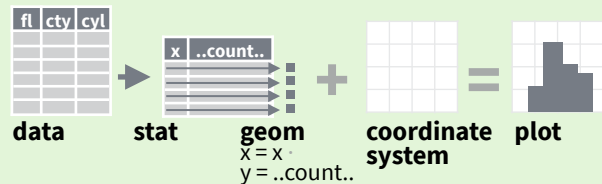
- l + geom\_raster**(aes(fill = z), hjust = 0.5, vjust = 0.5, interpolate = FALSE) - x, y, alpha, fill

- l + geom\_tile**(aes(fill = z)) - x, y, alpha, color, fill, linetype, size, width

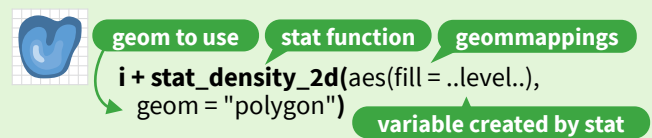
# Stats

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.



```
c + stat_bin(binwidth = 1, boundary = 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() + xlim(-5, 5) + stat_function(fun = dnorm,
n = 20, geom = "point") x | ..x.., ..y..

ggplot() + stat_qq(aes(sample = 1:100))
x, y, sample | ..sample.., ..theoretical..

e + stat_sum() x, y, size | ..n.., ..prop..

e + stat_summary(fun.data = "mean_cl_boot")

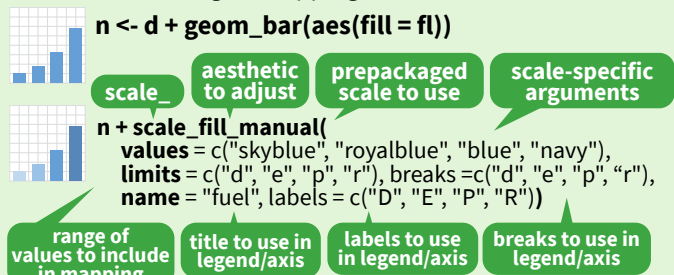
h + stat_summary_bin(fun = "mean", geom = "bar")

e + stat_identity()

e + stat_unique()
```

# Scales

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



## GENERAL PURPOSE SCALES

Use with most aesthetics

**scale\_\*\_continuous()** - Map cont' values to visual ones.  
**scale\_\*\_discrete()** - Map discrete values to visual ones.  
**scale\_\*\_binned()** - Map continuous values to discrete bins.  
**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 values as date times.  
Same as **scale\_\*\_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 the direction of the x axis.  
**scale\_x\_sqrt()** - Plot x on square root scale.

## COLOR AND FILL SCALES (DISCRETE)

**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(colors = 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.

ggplot(mpg, aes(y = fl)) + geom_bar()
Flip cartesian coordinates by switching
x and y aesthetic mappings.

r + coord_polar(theta = "x", direction=1)
theta, start, direction - Polar coordinates.

r + coord_trans(y = "sqrt") - x, y, xlim, ylim
Transformed cartesian coordinates. Set xtrans
and ytrans to the name of a window function.

pi + coord_quickmap()
pi + coord_map(projection = "ortho", orientation
= c(41, -74, 0)) - projection, 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()
r + theme_minimal()
r + theme_void()
Minimal theme.
Empty theme.

r + theme_gray()
Grey background
(default theme).

r + theme_dark()
Dark for contrast.
```

**r + theme()** Customize aspects of the theme such as axis, legend, panel, and facet properties.  
**r + ggtitle("Title") + theme(plot.title.position = "plot")**  
**r + theme(panel.background = element\_rect(fill = "blue"))**

# 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 label:

```
t + facet_grid(cols = vars(fl), labeller = label_both)
fl: c fl: d fl: e fl: p fl: r

t + facet_grid(rows = vars(fl),
labeller = label_bquote(alpha ^ .(fl)))
alpha^c alpha^d alpha^e alpha^p alpha^r
```

# Labels and Legends

Use **labs()** to label the elements of your plot.

```
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",
alt = "Add alt text to the plot",
<AES> = "New <AES> legend title")
```

**t + annotate(geom = "text", x = 8, y = 9, label = "A")**  
Places a geom with manually selected aesthetics.

**p + guides(x = guide\_axis(n.dodge = 2))** Avoid crowded or overlapping labels with **guide\_axis(n.dodge or angle)**.

**n + guides(fill = "none")** Set legend type for each aesthetic: colorbar, legend, or none (no legend).

**n + theme(legend.position = "bottom")**  
Place legend at "bottom", "top", "left", or "right".

**n + scale\_fill\_discrete(name = "Title",**  
**labels = c("A", "B", "C", "D", "E"))**  
Set legend title and labels with a scale function.

# Zooming

```
Without clipping (preferred):
t + coord_cartesian(xlim = c(0, 100), ylim = c(10, 20))

With clipping (removes unseen data points):
t + xlim(0, 100) + ylim(10, 20)
t + scale_x_continuous(limits = c(0, 100)) +
scale_y_continuous(limits = c(0, 100))
```