These materials adapted by Amelia McNamara from the RStudio CC BY-SA materials Introduction to R (2014) and Master the Tidyverse (2017).

Introduction to R & RStudio: deck 04: Syntax

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Syntax is the set of rules that govern what code works and doesn't work in a programming language. Most programming languages offer one standardized syntax, but R allows package developers to specify their own syntax. As a result, there is a large variety of (equally valid) R syntaxes.

R Syntax Comparison : : CHEAT SHEET

I've given you a copy of this cheatsheet in the "cheatsheets" folder of your workspace, and I have paper copies for anyone who wants one

Dollar sign syntax

```
goal(data$x, data$y)
```

SUMMARY STATISTICS:

one continuous variable:
```
mean(mtcars$mpg)
```
one categorical variable:
```
table(mtcars$cyl)
```
two categorical variables:
```
table(mtcars$cyl, mtcars$am)
```
one continuous, one categorical:
```
mean(mtcars$mpg[mtcars$cyl==4])
mean(mtcars$mpg[mtcars$cyl==6])
mean(mtcars$mpg[mtcars$cyl==8])
```

PLOTTING:

one continuous variable:
```
hist(mtcars$disp)

boxplot(mtcars$disp)
```
one categorical variable:
```
barplot(table(mtcars$cyl))
```
two continuous variables:
```
plot(mtcars$disp, mtcars$mpg)
```
two categorical variables:
```
mosaicplot(table(mtcars$am, mtcars$cyl))
```
one continuous, one categorical:
```
histogram(mtcars$disp[mtcars$cyl==4])
histogram(mtcars$disp[mtcars$cyl==6])
histogram(mtcars$disp[mtcars$cyl==8]

boxplot(mtcars$disp[mtcars$cyl==4
boxplot(mtcars$disp[mtcars$cyl=
boxplot(mtcars$disp[mtcars$cy
```

WRANGLING:

subsetting:
```
mtcars[mtcars$mpg>30,
```
making a new variable:
```
mtcars$efficien
mtcars$effici
```

Formula syntax

```
goal(y~x|z, data=data, group=w)
```

SUMMARY STATISTICS:

one continuous variable:
```
mosaic::mean(~mpg, data=mtcars)
```
one categorical variable:
```
mosaic::tally(~cyl, data=mtcars)
```
two categorical variables:
```
mosaic::tally(cyl~am, data=mtcars)
```
one continuous, one categorical:
```
mosaic::mean(mpg~cyl, data=mtcars)
```
tilde

PLOTTING:

one continuous variable:
```
lattice::histogram(~disp,

lattice::bwplot(~disp,
```
one categorical variable:
```
mosaic::bargraph(
```
two continuous v
```
lattice::xy
```
two cate
```
mosai
                    group=cyl)
```
o
```
                    data=mtcars)

                    data=mtcars)
```

R syntaxes give
ways to "say" the
ing

ead **across** the cheatsheet to see how different syntaxes approach the same problem

Tidyverse synta

SUMMARY STATISTIC

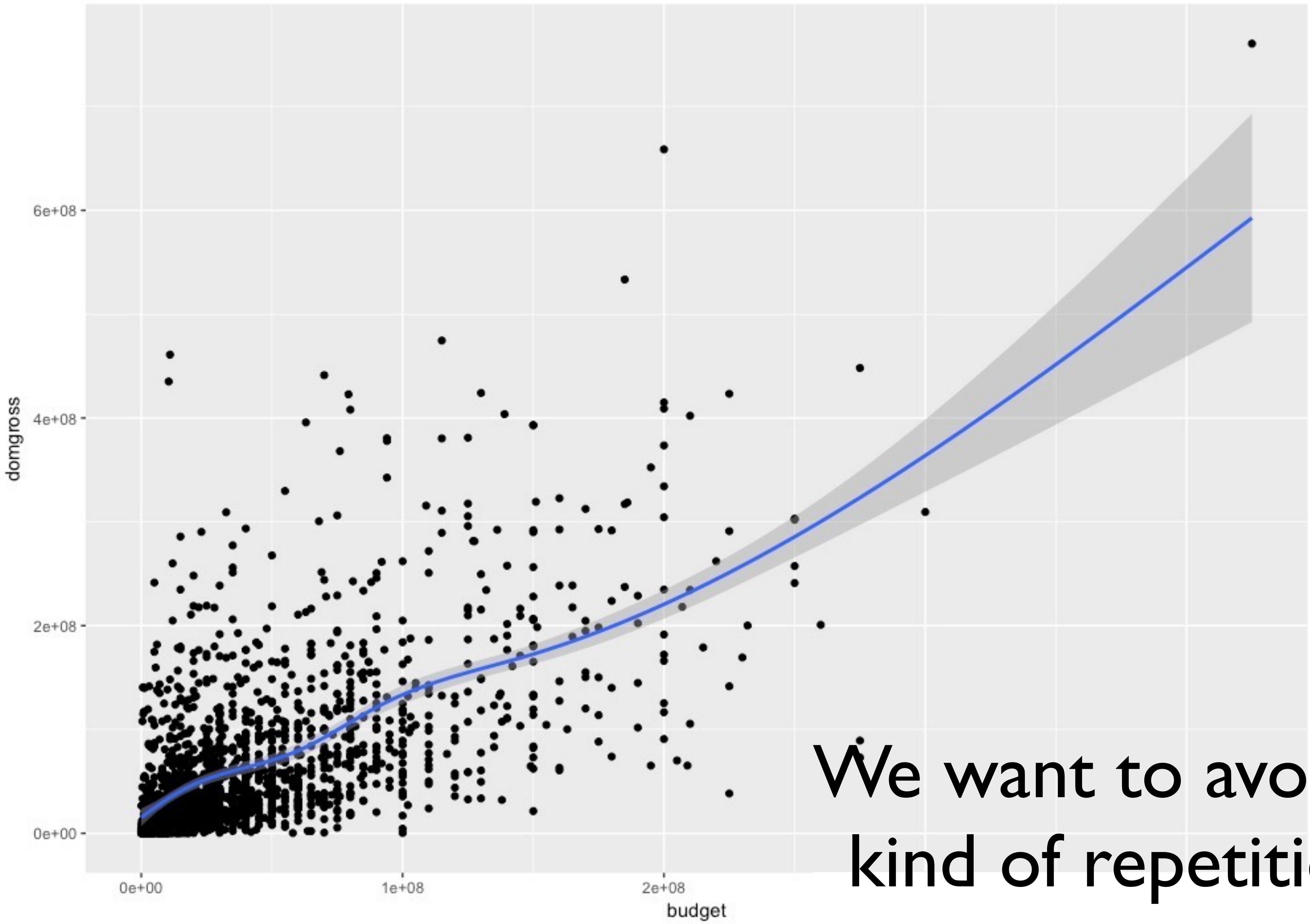
one continuous v
```
mtcars %
```
one cate
```
mtc
                  %>%
```
the pipe
```
                y(cyl, am) %>%
```
cal:
```
:group_by(cyl) %>%
ize(mean(mpg))
```
ariable:
```
plot(x=mpg, data=mtcars, geom = "histogram")

::qplot(y=disp, x=1, data=mtcars, geom="boxplot")
```
categorical variable:
```
ggplot2::qplot(x=cyl, data=mtcars, geom="bar")
```
two continuous variables:
```
ggplot2::qplot(x=disp, y=mpg, data=mtcars, geom="point")
```
two categorical variables:
```
ggplot2::qplot(x=factor(cyl), data=mtcars, geom="bar") +
        facet_grid(.~am)
```
one continuous, one categorical:
```
ggplot2::qplot(x=disp, data=mtcars, geom = "histogram") +
        facet_grid(.~cyl)

ggplot2::qplot(y=disp, x=factor(cyl), data=mtcars,
              geom="boxplot")
```

WRANGLING:

subsetting:
```
mtcars %>% dplyr::filter(mpg>30)
```
making a new variable:
```
mtcars <- mtcars %>%
dplyr::mutate(efficient = if_else(mpg>30,  TRUE, FALSE))
```

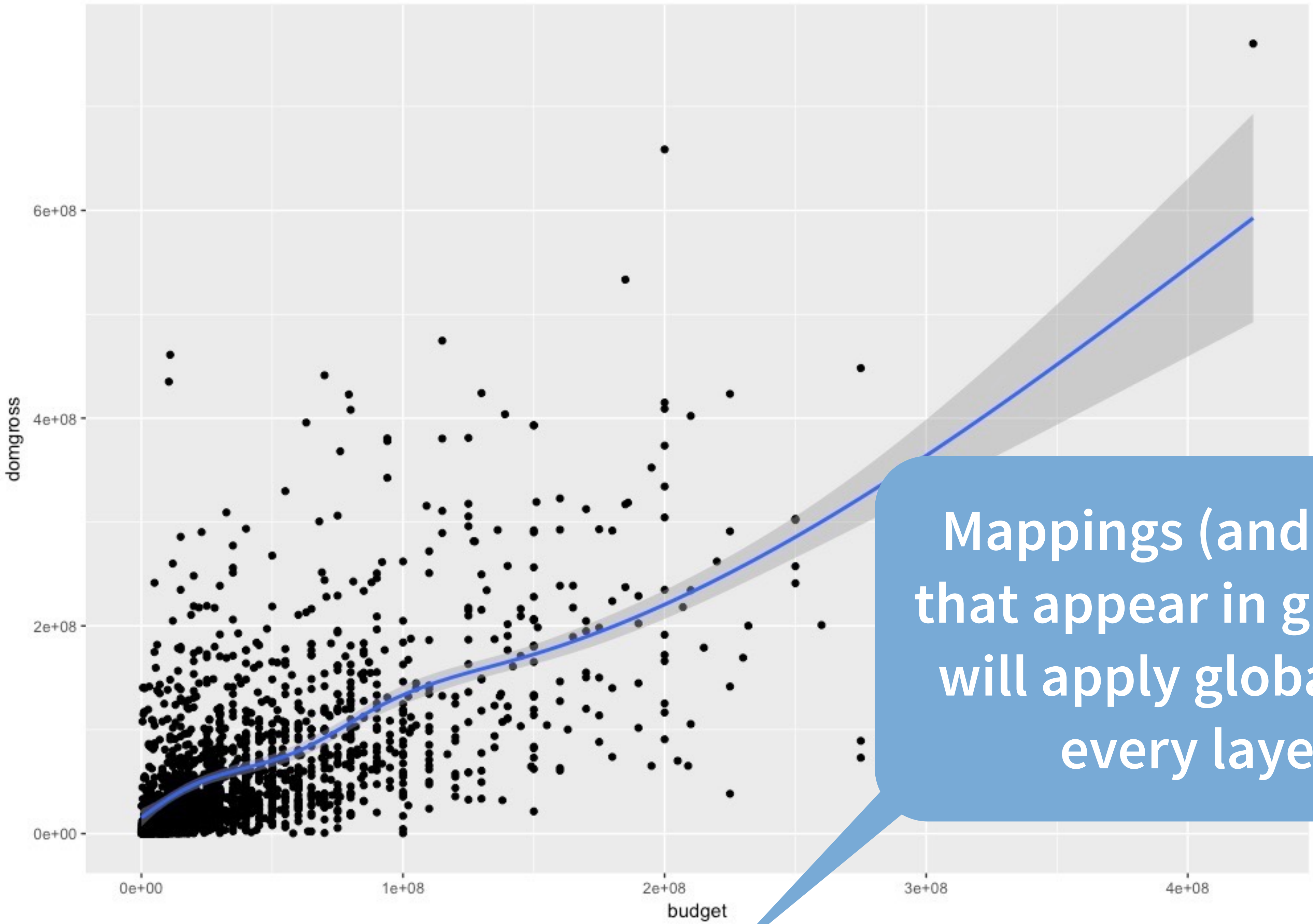
SMITH C

within
ggplot2



We want to avoid this kind of repetition in programming

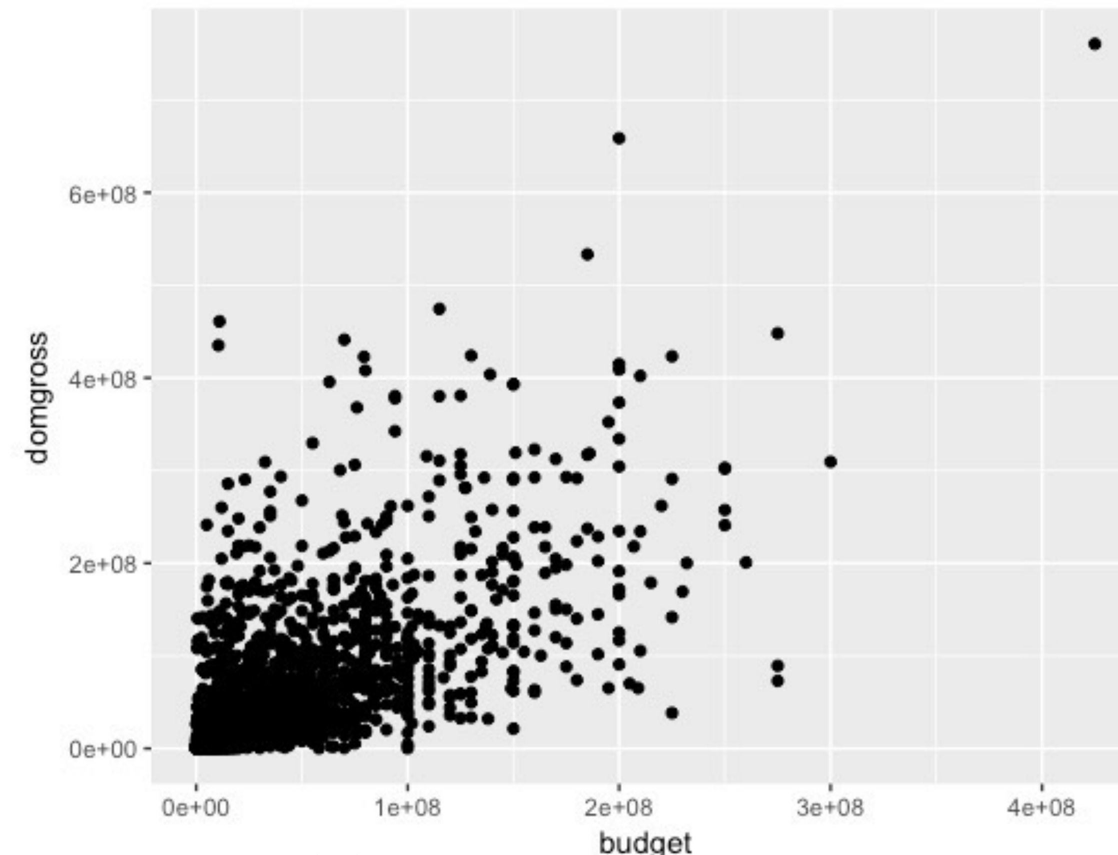
```
ggplot(data = bechdel) +
  geom_point(mapping = aes(x = budget, y = domgross)) +
  geom_smooth(mapping = aes(x= budget, y = domgross))
```



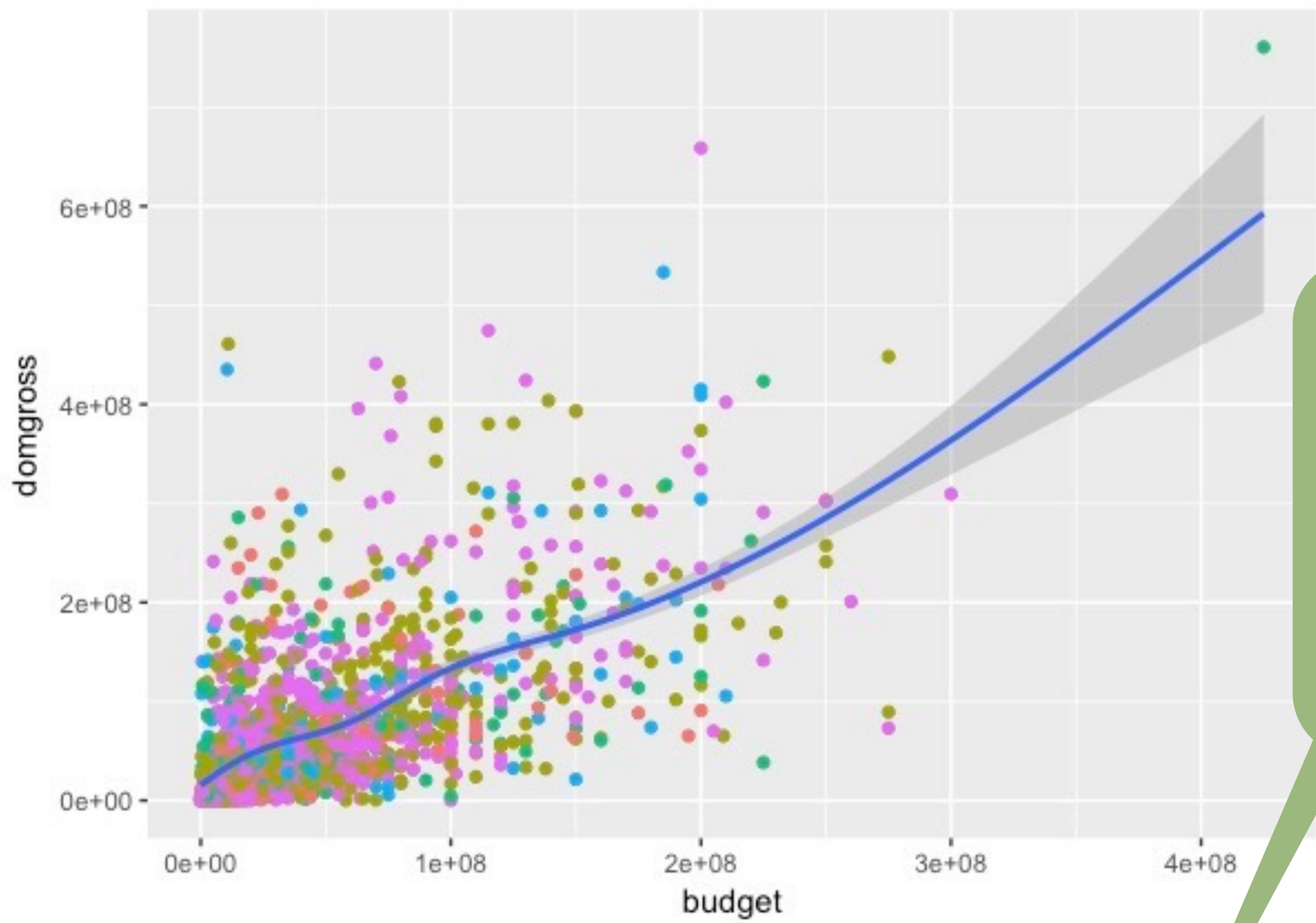
Mappings (and data) that appear in ggplot() will apply globally to every layer

```
ggplot(data = bechdel, aes(x= budget, y = domgross)) +
  geom_point() +
  geom_smooth()
```

MANY ways to say the same thing



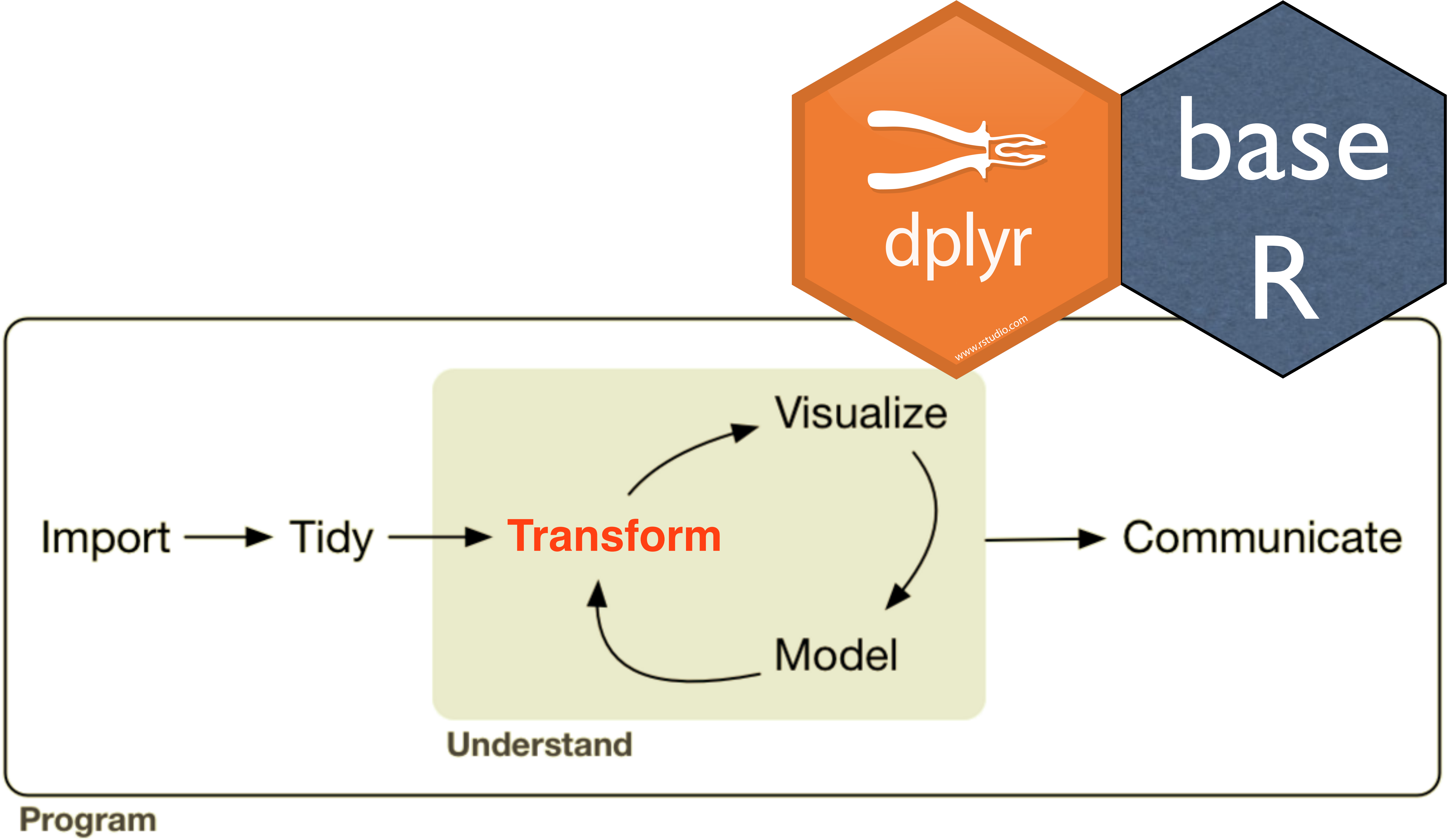

```
ggplot(bechdel) +
    geom_point(aes(x = budget, y = domgross))
ggplot(bechdel, aes(x = budget, y = domgross)) +
    geom_point()
ggplot(bechdel, aes(x= budget)) +
    geom_point(aes(y = domgross))
ggplot() +
    geom_point(bechdel, aes(x = budget, y = domgross))
```



Mappings (and data) that appear in a geom_ function will add to or override the global mappings for that layer

```
ggplot(data = bechdel, aes(x= budget, y = domgross)) +
  geom_point(aes(color=clean_test)) +
  geom_smooth()
```

Subsetting



From *R for Data Science* by Hadley Wickham and Garrett Grolemund.

Toy data

```
beatles <- data.frame(
  name = c("John", "Paul", "George", "Ringo"),
  birth = c(1940, 1942, 1943, 1940),
  instrument = c("guitar", "bass", "guitar", "drums")
)
```

First— the tidyverse way: dplyr

dplyr methods for isolating data

select() - extract **variables**

filter() - extract **cases**

arrange() - reorder **cases**

select()

Extract columns by name.

```
select(.data, …)
```

data frame to transform

name(s) of columns to extract
(or a select helper function)

select()

Extract columns by name.

```
select(beatles, name, birth)
```

name	birth	instrument
John	1940	guitar
Paul	1942	base
George	1943	guitar
Ringo	1940	drums

→

name	birth
John	1940
Paul	1942
George	1943
Ringo	1940

dplyr

Your Turn 1

Alter the code to select just the **instrument** column:

```
select(beatles, name, birth)
```

select() helpers

: - Select range of columns

```
select(storms, storm:pressure)
```

- - Select every column but

```
select(storms, -c(storm, pressure))
```

starts_with() - Select columns that start with…

```
select(storms, starts_with("w"))
```

ends_with() - Select columns that end with…

```
select(storms, ends_with("e"))
```

select() helpers

contains() - Select columns whose names contain…

```
select(storms, contains("d"))
```

matches() - Select columns whose names match regular expression

```
select(storms, matches("^.{4}$"))
```

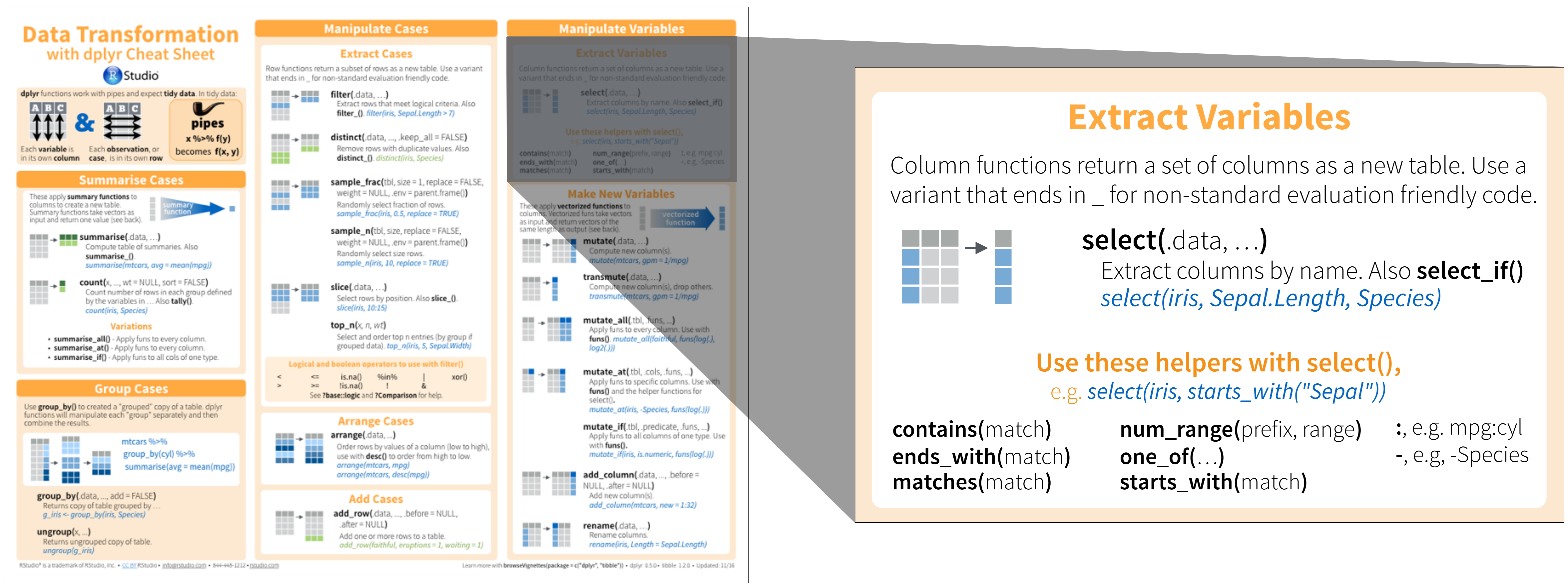
one_of() - Select columns whose names are one of a set

```
select(storms, one_of(c("storm", "storms", "Storm")))
```

num_range() - Select columns named in prefix, number style

```
select(storms, num_range("x", 1:5))
```

select() helpers



Now, the base R way: brackets and dollar signs

Base R bracket subset notation

in base R, you use the same syntax to

extract **variables**

extract **cases**

name of object to subset

brackets
(brackets always mean subset)

vec[ ]

base R

Subset notation

name of
object to
subset

vec

base
R

Subset notation

name of object to subset

brackets
(brackets always mean subset)

vec[?]

an index
(that tells R which elements to include)

base R

Each dimension needs its own index!

vec[?]

6	1	3	6	10	5

Each dimension needs its own index!

vec[?]

6	1	3	6	10	5

base R

Each dimension needs its own index!

vec[?]

beatles[?,?]

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

base R

Each dimension needs its own index!

vec[?]
beatles[?,?]

which **rows** to include

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

base R

Each dimension needs its own index!

```
vec[?]
beatles[?,?]
```

which **rows** to include

which **columns** to include

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

base R

Each dimension needs its own index!

```
vec[?]
beatles[?,?]
```

which **rows** to include

separate dimensions with a **comma**

which **columns** to include

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

base R

Each dimension needs its own index!

```
vec[?]
beatles[?,?]
```

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

What goes in the indexes?

Four ways to subset

1. Integers
2. Blank spaces
3. Names
4. Logical vectors (TRUE and FALSE)

Integers (positive)

Positive integers behave just like *ij* notation in linear algebra

beatles[?,?]

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

base R

Integers (positive)

Positive integers behave just like *ij* notation in linear algebra

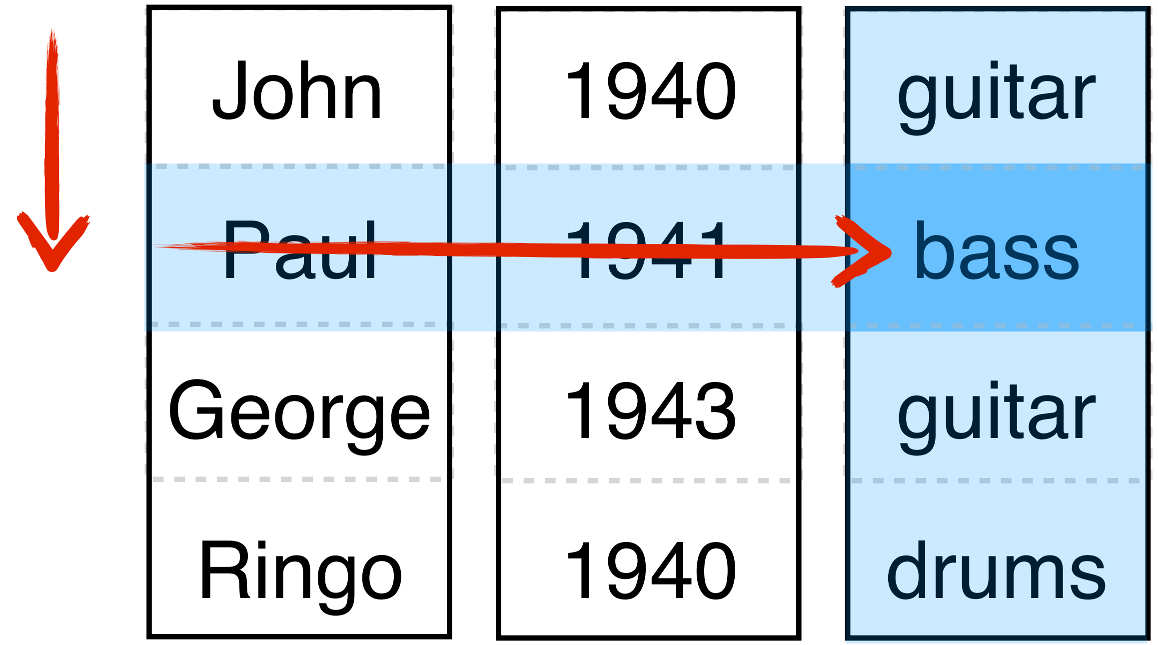
beatles[2,?]

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

Integers (positive)

Positive integers behave just like *ij* notation in linear algebra

beatles[2,3]



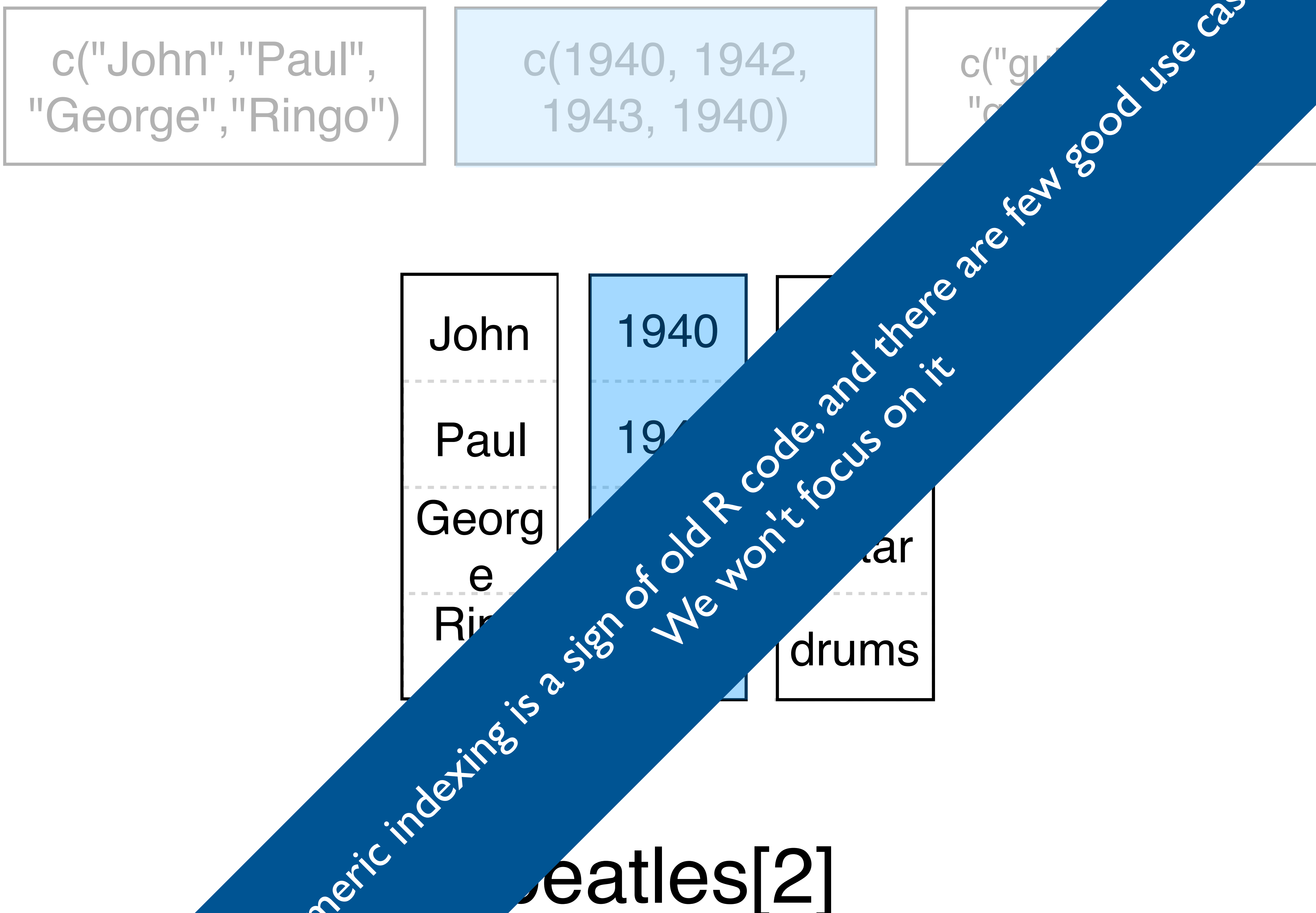
base R

Integers (positive)

Positive integers behave just like *ij* notation in linear algebra

beatles[2,3]

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums



Numeric indexing is a sign of old R code, and there are few good use cases

We won't focus on it

Names

If your object has names, you can ask for elements or columns back by name.

```
beatles[ ,"birth"]
```

name	birth	instrument
John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

base R

Names

If your object has names, you can ask for elements or columns back by name.

```
beatles[ ,c("name","birth")]
```

name	birth	instrument
John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

$

The most common syntax for subsetting lists and data frames

base R

name	birth	instrument
John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

beatles$birth

base R

name	birth	instrument
John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

beatles$birth

name of
data frame

base
R

name	birth	instrument
John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

beatles$birth

name of data frame

$

base R

name	birth	instrument
John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

beatles$birth

name of data frame

$

name of column
(no quotes)

base R

name	birth	instrument
John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

c(1940, 1941, 1943, 1940)

beatles$birth

name of data frame

$

name of column
(no quotes)

base R

Back to the tidyverse

dplyr methods for isolating data

select() - extract **variables**
filter() - extract **cases**
arrange() - reorder **cases**

filter()

Extract rows that meet logical criteria.

```
filter(.data, … )
```

data frame to transform

one or more logical tests (filter returns each row for which the test is TRUE)

dplyr

common syntax

Each function takes a data frame / tibble as its first argument and returns a data frame / tibble.

```
filter(.data, … )
```

dplyr function

data frame to transform

function specific arguments

filter()

Extract rows that meet logical criteria.

```
filter(beatles, name == "George")
```

name	birth	instrument
John	1940	guitar
Paul	1942	base
George	1943	guitar
Ringo	1940	drums

→

George	1943	guitar

dplyr

filter()

Extract rows that meet logical criteria.

```
filter(beatles, name == "George")
```

name	birth	instrument
John	1940	guitar
Paul	1942	base
George	1943	guitar
Ringo	1940	drums

= sets
(returns nothing)

== tests if equal
(returns TRUE or FALSE)

dplyr

Logical comparisons

Logical comparisons

?Comparison

`x < y`	Less than
`x > y`	Greater than
`x == y`	Equal to
`x <= y`	Less than or equal to
`x >= y`	Greater than or equal to
`x != y`	Not equal to
`x %in% y`	Group membership
`is.na(x)`	Is NA
`!is.na(x)`	Is not NA

base R

dplyr

Logical comparisons

What will these return?

1 < 3

1 > 3

c(1, 2, 3, 4, 5) > 3

%in%

```
# What does this do?
1 %in% c(1, 2, 3, 4)
1 %in% c(2, 3, 4)
c(3,4,5,6) %in% c(2, 3, 4)
```

base R

dplyr

%in%

%in% tests whether the object on the left is a member of the group on the right.

```
1 %in% c(1, 2, 3, 4)
# TRUE
1 %in% c(2, 3, 4)
# FALSE
c(3,4,5,6) %in% c(2, 3, 4)
# TRUE TRUE FALSE FALSE
```

Your turn

x <- c(1, 2, 3, 4, 5)

Operator	Result	Comparison
x > 3	`c(F, F, F, T, T)`	greater than
x >= 3		
x < 3		
x <= 3		
x == 3		
x != 3		
x = 3		

01:00

Your turn

x <- c(1, 2, 3, 4, 5)

Operator	Result	Comparison
x > 3	`c(F, F, F, T, T)`	greater than
x >= 3	`c(F, F, T, T, T)`	greater than or equal to
x < 3		
x <= 3		
x == 3		
x != 3		
x = 3		

Your turn

x <- c(1, 2, 3, 4, 5)

Operator	Result	Comparison
x > 3	`c(F, F, F, T, T)`	greater than
x >= 3	`c(F, F, T, T, T)`	greater than or equal to
x < 3	`c(T, T, F, F, F)`	less than
x <= 3		
x == 3		
x != 3		
x = 3		

Your turn

x <- c(1, 2, 3, 4, 5)

Operator	Result	Comparison
x > 3	`c(F, F, F, T, T)`	greater than
x >= 3	`c(F, F, T, T, T)`	greater than or equal to
x < 3	`c(T, T, F, F, F)`	less than
x <= 3	`c(T, T, T, F, F)`	less than or equal to
x == 3		
x != 3		
x = 3		

Your turn

x <- c(1, 2, 3, 4, 5)

Operator	Result	Comparison
x > 3	`c(F, F, F, T, T)`	greater than
x >= 3	`c(F, F, T, T, T)`	greater than or equal to
x < 3	`c(T, T, F, F, F)`	less than
x <= 3	`c(T, T, T, F, F)`	less than or equal to
x == 3	`c(F, F, T, F, F)`	equal to
x != 3		
x = 3		

Your turn

x <- c(1, 2, 3, 4, 5)

Operator	Result	Comparison
x > 3	`c(F, F, F, T, T)`	greater than
x >= 3	`c(F, F, T, T, T)`	greater than or equal to
x < 3	`c(T, T, F, F, F)`	less than
x <= 3	`c(T, T, T, F, F)`	less than or equal to
x == 3	`c(F, F, T, F, F)`	equal to
x != 3	`c(T, T, F, T, T)`	not equal to
x = 3		

Your turn

x <- c(1, 2, 3, 4, 5)

Operator	Result	Comparison
x > 3	`c(F, F, F, T, T)`	greater than
x >= 3	`c(F, F, T, T, T)`	greater than or equal to
x < 3	`c(T, T, F, F, F)`	less than
x <= 3	`c(T, T, T, F, F)`	less than or equal to
x == 3	`c(F, F, T, F, F)`	equal to
x != 3	`c(T, T, F, T, T)`	not equal to
x = 3		same as <-

Your Turn 2

Alter the code to filter out just rows where birth is 1940:

```
filter(beatles, name == "George")
```

filter()

Extract rows that meet *every* logical criteria.

```
filter(beatles, birth==1940, instrument == "guitar")
```

name	birth	instrument
John	1940	guitar
Paul	1942	base
George	1943	guitar
Ringo	1940	drums

→

John	1940	guitar

Boolean operators

Boolean operators

?base::Logic

`a & b`	and
`a | b`	or
`xor(a, b)`	exactly or
`!a`	not

Boolean operators

You can combine logical tests with &, |, xor, !, any, and all

x > 2 & x < 9

Boolean operators

You can combine logical tests with &, |, xor, !, any, and all

x > 2 & x < 9

TRUE &

Boolean operators

You can combine logical tests with &, |, xor, !, any, and all

x > 2 & x < 9

TRUE & TRUE

Boolean operators

You can combine logical tests with &, |, xor, !, any, and all

x > 2 & x < 9

TRUE & TRUE

TRUE

&

Are both condition 1 **and** condition 2 true?

expression	outcome
TRUE & TRUE	TRUE
TRUE & FALSE	FALSE
FALSE & TRUE	FALSE
FALSE & FALSE	FALSE

base R

dplyr

|

Is either condition 1 **or** condition 2 true?

<table>
<tr><th>expression</th><th>outcome</th></tr>
<tr><td>TRUE | TRUE</td><td>TRUE</td></tr>
<tr><td>TRUE | FALSE</td><td>TRUE</td></tr>
<tr><td>FALSE | TRUE</td><td>TRUE</td></tr>
<tr><td>FALSE | FALSE</td><td>FALSE</td></tr>
</table>

base R

dplyr

xor

Is either condition 1 **or** condition 2 true, **but not both**?

expression	outcome
xor(TRUE, TRUE)	FALSE
xor(TRUE, FALSE)	TRUE
xor(FALSE, TRUE)	TRUE
xor(FALSE, FALSE)	FALSE

!

Negation

expression	outcome
!(TRUE)	FALSE
!(FALSE)	TRUE

filter()

Extract rows that meet *every* logical criteria.

```
filter(beatles, birth==1940 & instrument == "guitar")
```

name	birth	instrument
John	1940	guitar
Paul	1942	base
George	1943	guitar
Ringo	1940	drums

→

John	1940	guitar

dplyr

Base R

Logical

You can subset with a logical vector of the same length as the dimension you are subsetting. Each element that corresponds to a TRUE will be returned.

beatles[c(FALSE,**TRUE**,**TRUE**,FALSE),]

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

Logical

You can subset with a logical vector of the same length as the dimension you are subsetting. Each element that corresponds to a TRUE will be returned.

```
beatles[c(FALSE,TRUE,TRUE,FALSE), ]
```

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

base R

Logical

You can provide a statement that **evaluates** to a logical to get something similar to a `dplyr` `filter()` statement.

beatles[beatles$birth == 1940,]

beatles[**c(TRUE, FALSE, FALSE, TRUE)**,]

John	1940	guitar
Paul	1941	bass
George	1943	guitar
Ringo	1940	drums

base R

Logical tests

?Comparison

`x < y`	Less than
`x > y`	Greater than
`x == y`	Equal to
`x <= y`	Less than or equal to
`x >= y`	Greater than or equal to
`x != y`	Not equal to
`x %in% y`	Group membership
`is.na(x)`	Is NA
`!is.na(x)`	Is not NA

Boolean operators

?base::Logic

`a & b`	and
`a	b`	or
`xor(a, b)`	exactly or
`!a`	not

base R

dplyr

Bigger example

Baby names

We'll play with the `babynames` dataset in R. It comes in its own package, so you will need to load the package (what command does that?) and then View the data

Filter

	year	sex	name	n	prop
1	1880	F	Mary	7065	0.072384329
2	1880	F	Anna	2604	0.026679234
3	1880	F	Emma	2003	0.020521700
4	1880	F	Elizabeth	1939	0.019865989
5	1880	F	Minnie	1746	0.017888611
6	1880	F	Margaret	1578	0.016167370
7	1880	F	Ida	1472	0.015081349
8	1880	F	Alice	1414	0.014487111
9	1880	F	Bertha	1320	0.013524036
10	1880	F	Sarah	1288	0.013196180
11	1880	F	Annie	1258	0.012888816
12	1880	F	Clara	1226	0.012560961
13	1880	F	Ella	1156	0.011843777
14	1880	F	Florence	1063	0.010890947
15	1880	F	Cora	1045	0.010706528

Your Turn 3

See if you can use filter and/or select to get just the babies with your first name. (If you have a name with less than 5 occurrences in the US in any year, pick a neighbor's name.)

01:00

Your Turn 4

See if you can use the logical operators to show:

- All of the names where **prop** is greater than or equal to 0.08
- All of the children named “Sea”
- All of the names that have a missing value for **n**

  (Hint: this should return an empty data set).

04:00

```
filter(babynames, prop >= 0.08)
#     year    sex     name       n         prop
# 1   1880      M     John    9655 0.08154630
# 2   1880      M William    9531 0.08049899
# 3   1881      M     John    8769 0.08098299
```

```
filter(babynames, name == "Sea")
#     year    sex   name      n          prop
# 1   1982      F    Sea      5  2.756771e-06
# 2   1985      M    Sea      6  3.119547e-06
# 3   1986      M    Sea      5  2.603512e-06
# 4   1998      F    Sea      5  2.580377e-06
```

```
filter(babynames, is.na(n))
#   0 rows
```

Two common mistakes

1. Using = instead of ==

```
filter(babynames, name = "Sea")
filter(babynames, name == "Sea")
```

2. Forgetting quotes

```
filter(babynames, name == Sea)
filter(babynames, name == "Sea")
```

Your Turn 5

Use Boolean operators to alter the code below to return only the rows that contain:

- Girls named Sea
- Names that were used by exactly 5 or 6 children in 1880
- Names that are one of Acura, Lexus, or Yugo

```
filter(babynames, name == "Sea" | name == "Anemone")
```

```
filter(babynames, name == "Sea", sex == "F")
#     year    sex   name      n          prop
# 1   1982      F    Sea      5  2.756771e-06
# 2   1998      F    Sea      5  2.580377e-06
```

```
filter(babynames, n == 5 | n == 6, year == 1880)
#     year    sex      name      n          prop
# 1   1880      F      Abby      6  6.147289e-05
# 2   1880      F    Aileen      6  6.147289e-05
# …      …      …         …      …             …
```

```
filter(babynames, name %in% c("Acura", "Lexus", "Yugo"))
#     year    sex   name      n          prop
# 1   1990      F  Lexus     36  1.752932e-05
# 2   1990      M  Lexus     12  5.579156e-06
# …      …      …      …      …             …
```

Two more common mistakes

3. Collapsing multiple tests into one

```
filter(babynames, 10 < n < 20)
filter(babynames, 10 < n, n < 20)
```

4. Stringing together many tests (when you could use %in%)

```
filter(babynames, n == 5 | n == 6 | n == 7 | n == 8)
filter(babynames, n %in% c(5, 6, 7, 8))
```

Saving results

Saving results

Print to screen

```
filter(babynames, name %in% c("Acura", "Lexus", "Yugo"))
#     year   sex  name     n       prop
# 1   1990     F Lexus    36 1.752932e-05
# 2   1990     M Lexus    12 5.579156e-06
# …      …     …     …     …            …
```

Save to new data frame (where does this appear?)

```
carnames <- filter(babynames, name %in% c("Acura", "Lexus", "Yugo"))
```

Save over existing data frame (dangerous!)

```
babynames <- filter(babynames, name %in% c("Acura", "Lexus", "Yugo"))
```

```
babynames <- filter(babynames, name %in% c("Acura", "Lexus", "Yugo"))
```

Uh oh…

```
rm(babynames)
str(babynames)
```

Phew!

Your Turn 5

Try to:

- Filter out the `babynames` data for your name. (You may want to **also** filter for your gender)
- Assign that data its own name
- Use your subsetted data to create a `ggplot` graphic of the popularity of your name over time

```
amelia <- babynames %>%
    filter(name=="Amelia" & sex == "F")

ggplot(amelia) + geom_point(aes(x=year, y=n))

ggplot(amelia) + geom_line(aes(x=year, y=n))
```