

Tidy data with `tidyverse`

Data Wrangling: Session 4

Kieran Healy

Statistical Horizons, October 2023

Load the packages, as always

```
library(here)      # manage file paths  
library(socviz)    # data and some useful functions  
  
library(tidyverse) # your friend and mine  
library(gapminder) # gapminder data
```

**Tidy data
is data in
long format**

The Tidyverse wants to be fed **tidy data**



Get your data into long-form

Very, very often, the solution to some data-wrangling problem in Tidyverse-focused workflow is:

Get your data into long-form

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First, get the data into long format.

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Then do the recoding thing that you want.

Get your data into long-form

Very, very often, the solution to some data-wrangling problem in Tidyverse-focused workflow is:

First, get the data into long format.

Then do the recoding thing that you want.

Then transform it back to something wider if needed.

This isn't an *iron* rule

As we'll see later, `dplyr` is able to do "rowwise" operations if you need them.

**It is a
pretty good
rule though**

Tidy data

gapminder

```
## # A tibble: 1,704 × 6
##   country    continent  year lifeExp      pop gdpPercap
##   <fct>      <fct>    <int>  <dbl>     <int>     <dbl>
## 1 Afghanistan Asia      1952    28.8  8425333    779.
## 2 Afghanistan Asia      1957    30.3  9240934    821.
## 3 Afghanistan Asia      1962    32.0  10267083   853.
## 4 Afghanistan Asia      1967    34.0  11537966   836.
## 5 Afghanistan Asia      1972    36.1  13079460   740.
## 6 Afghanistan Asia      1977    38.4  14880372   786.
## 7 Afghanistan Asia      1982    39.9  12881816   978.
## 8 Afghanistan Asia      1987    40.8  13867957   852.
## 9 Afghanistan Asia      1992    41.7  16317921   649.
## 10 Afghanistan Asia     1997    41.8  22227415   635.
## # i 1,694 more rows
```

Tidy data

gdp	lifexp	pop	continent
340	65	31	Euro
227	51	200	Amer
909	81	80	Euro
126	40	20	Asia

Tidy data

country	year	cases	population
Afghanistan	1990	745	1037071
Afghanistan	2000	2666	20595360
Brazil	1999	37737	172006362
Brazil	2000	80488	174504898
China	1999	212258	1272915272
China	2000	213766	128042583

variables

country	year	cases	population
Afghanistan	1990	745	1037071
Afghanistan	2000	2666	20595360
Brazil	1999	37737	172006362
Brazil	2000	80488	174504898
China	1999	212258	1272915272
China	2000	213766	128042583

observations

country	year	cases	population
Afghanistan	1990	745	1037071
Afghanistan	2000	2666	20595360
Brazil	1999	37737	172006362
Brazil	2000	80488	174504898
China	1999	212258	1272915272
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values

Tidy data

Each variable has its own column.

Each observation has its own row.

Each value has its own cell.

Tidy data

Each variable has its own column.

Each observation has its own row.

Each value has its own cell.

When data is tidy in this way, the vectorized character of R's way of doing things works best.

Untidy data is common for good reasons

Table A-1. Years of School Completed by People 25 Years and Over, by Age and Sex: Selected Years 1940 to 2016

(Numbers in thousands. Noninstitutionalized population except where otherwise specified.)

Age, sex, and years	Total	Years of School Completed					
		Elementary		High school		College	
		0 to 4 years	5 to 8 years	1 to 3 years	4 years	1 to 3 years	4 years or more

25 YEARS AND OLDER

Male

2016	103,372	1,183	3,513	7,144	30,780	26,468	34,283	(NA)
2015	101,887	1,243	3,669	7,278	30,997	25,778	32,923	(NA)
2014	100,592	1,184	3,761	7,403	30,718	25,430	32,095	(NA)
2013	99,305	1,127	3,836	7,314	30,014	25,283	31,731	(NA)
2012	98,119	1,237	3,879	7,388	30,216	24,632	30,766	(NA)
2011	97,220	1,234	3,883	7,443	30,370	24,319	29,971	(NA)
2010	96,325	1,279	3,931	7,705	30,682	23,570	29,158	(NA)
2009	95,518	1,372	4,027	7,754	30,025	23,634	28,706	(NA)
2008	94,470	1,310	4,136	7,853	29,491	23,247	28,433	(NA)
2007	93,421	1,458	4,249	8,294	29,604	22,219	27,596	(NA)
2006	92,233	1,472	4,395	7,940	29,380	22,136	26,910	(NA)
2005	90,899	1,505	4,402	7,787	29,151	21,794	26,259	(NA)

Untidy data is common for good reasons

Storing data in long form is often *inefficient*

```
library(covdata)
covus %>
  filter(state == "NY") %>
  select(date:fips, measure:count)

## # A tibble: 11,872 × 5
##   date      state fips  measure       count
##   <date>    <chr> <dbl> <chr>        <dbl>
## 1 2021-03-07 NY     36  positive     1681169
## 2 2021-03-07 NY     36  probable_cases NA
## 3 2021-03-07 NY     36  negative      NA
## 4 2021-03-07 NY     36  pending       NA
## 5 2021-03-07 NY     36  hospitalized_currently 4789
## 6 2021-03-07 NY     36  hospitalized_cumulative NA
## 7 2021-03-07 NY     36  in_icu_currently 999
## 8 2021-03-07 NY     36  in_icu_cumulative NA
## 9 2021-03-07 NY     36  on_ventilator_currently 682
## 10 2021-03-07 NY    36  on_ventilator_cumulative NA
## # i 11,862 more rows
```

Untidy data is common for good reasons

Storing data in wide form is *easier to display* in a printed table

```
library(palmerpenguins)
penguins %>
  group_by(species, island, year) %>
  summarize(bill = round(mean(bill_length_mm, na.rm = TRUE), 2)) %>
  knitr::kable()
```

species	island	year	bill
Adelie	Biscoe	2007	38.32
Adelie	Biscoe	2008	38.70
Adelie	Biscoe	2009	39.69
Adelie	Dream	2007	39.10
Adelie	Dream	2008	38.19
Adelie	Dream	2009	38.15
Adelie	Torgersen	2007	38.80
Adelie	Torgersen	2008	38.77
Adelie	Torgersen	2009	39.31
Chinstrap	Dream	2007	48.72

Untidy data is common for good reasons

Storing data in wide form is *easier to display* in a printed table

```
penguins >  
  group_by(species, island, year) >  
  summarize(bill = round(mean(bill_length_mm, na.rm = TRUE), 2)) >  
  pivot_wider(names_from = year, values_from = bill) >  
  knitr::kable()
```

species	island	2007	2008	2009
Adelie	Biscoe	38.32	38.70	39.69
Adelie	Dream	39.10	38.19	38.15
Adelie	Torgersen	38.80	38.77	39.31
Chinstrap	Dream	48.72	48.70	49.05
Gentoo	Biscoe	47.01	46.94	48.50

(Again, these tables are made directly in R with the code you see here.)

It's also common for *less* good reasons

State																		
A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q			
State	CD#	2018 Cook PVI Score	2018 Winner	Party	Dem Votes	GOP Votes	Other Votes	Dem %	GOP %	Other %	Dem Margin	2016 Clinton Margin	Swing vs. 2016 Prez	Raw Votes vs. 2016	Final?			
New House Breakdown: 235D, 199R, 1 Not Certified																		
Compiled by: David Wasserman & Ally Flinn, Cook Political Report. @Redistrict/@CookPolitical. <i>Italics</i> denotes freshman, Bold denotes party change.																		
Alabama	1	R+15	Bradley Byrne	R	89,226	153,228	163	36.8%	63.2%	0.1%	-26.4%	-29.2%	2.8%	79.3%	x			
Alabama	2	R+16	Martha Roby	R	86,931	138,879	420	38.4%	61.4%	0.2%	-23.0%	-31.7%	8.7%	78.7%	x			
Alabama	3	R+16	Mike Rogers	R	83,996	147,770	149	36.2%	63.7%	0.1%	-27.5%	-33.0%	5.5%	79.6%	x			
Alabama	4	R+30	Robert Aderholt	R	46,492	184,255	222	20.1%	79.8%	0.1%	-59.6%	-62.5%	2.9%	78.9%	x			
Alabama	5	R+18	Mo Brooks	R	101,388	159,063	222	38.9%	61.0%	0.1%	-22.1%	-32.9%	10.8%	82.8%	x			
Alabama	6	R+26	Gary Palmer	R	85,644	192,542	142	30.8%	69.2%	0.1%	-38.4%	-43.8%	5.4%	82.8%	x			
Alabama	7	D+20	Terri Sewell	D	185,010	0	4,153	97.8%	0.0%	2.2%	97.8%	41.2%	N/A	64.2%	x			
Alaska	AL	R+9	Don Young	R	131,199	149,779	1,188	46.5%	53.1%	0.4%	-6.6%	-14.7%	8.1%	88.6%	x			
Arizona	1	R+2	Tom O'Halleran	D	143,240	122,784	65	53.8%	46.1%	0.0%	7.7%	-1.1%	8.8%	92.0%	x			
Arizona	2	R+1	<i>Ann Kirkpatrick</i>	D	161,000	133,102	50	54.7%	45.2%	0.0%	9.5%	4.8%	4.7%	91.5%	x			
Arizona	3	D+13	Raul Grijalva	D	114,650	64,868	0	63.9%	36.1%	0.0%	27.7%	29.5%	-1.8%	84.8%	x			
Arizona	4	R+21	Paul Gosar	R	84,521	188,842	3,672	30.5%	68.2%	1.3%	-37.7%	-39.4%	1.7%	91.1%	x			
Arizona	5	R+15	Andy Biggs	R	127,027	186,037	0	40.6%	59.4%	0.0%	-18.8%	-20.5%	1.7%	91.7%	x			
Arizona	6	R+9	David Schweikert	R	140,559	173,140	0	44.8%	55.2%	0.0%	-10.4%	-9.8%	-0.6%	91.2%	x			
Arizona	7	D+23	Ruben Gallego	D	113,044	301	18,706	85.6%	0.2%	14.2%	85.4%	48.3%	N/A	79.0%	x			
Arizona	8	R+13	Debbie Lesko	R	135,569	168,835	13	44.5%	55.5%	0.0%	-10.9%	-20.8%	9.9%	91.5%	x			
Arizona	9	D+4	<i>Greg Stanton</i>	D	159,583	101,662	0	61.1%	38.9%	0.0%	22.2%	15.9%	6.3%	90.0%	x			
Arkansas	1	R+17	Rick Crawford	R	57,907	138,757	4,581	28.8%	68.9%	2.3%	-40.2%	-34.8%	-5.4%	77.2%	x			
Arkansas	2	R+7	French Hill	R	116,135	132,125	5,193	45.8%	52.1%	2.0%	-6.3%	-10.7%	4.4%	82.6%	x			
Arkansas	3	R+19	Steve Womack	R	74,952	148,717	6,039	32.6%	64.7%	2.6%	-32.1%	-31.4%	-0.7%	78.6%	x			
Arkansas	4	R+17	Bruce Westerman	R	63,984	136,740	4,168	31.2%	66.7%	2.0%	-35.5%	-32.8%	-2.7%	75.7%	x			
California	1	R+11	Doug LaMalfa	R	131,506	160,006	0	45.1%	54.9%	0.0%	-9.8%	-19.4%	9.6%	91.6%				
California	2	D+22	Jared Huffman	D	243,051	72,541	0	77.0%	23.0%	0.0%	54.0%	45.2%	8.8%	90.5%				
California	3	D+5	John Garamendi	D	132,983	96,106	0	58.0%	42.0%	0.0%	16.1%	12.5%	3.6%	86.8%				
California	4	R+10	<i>Tom McClintock</i>	R	156,253	184,401	0	45.9%	54.1%	0.0%	-8.3%	-14.5%	6.2%	94.6%				
California	5	D+21	Mike Thompson	D	203,012	0	53,836	79.0%	0.0%	21.0%	79.0%	44.6%	N/A	83.8%				
California	6	D+21	Doris Matsui	D	201,939	0	0	100.0%	0.0%	0.0%	100.0%	44.0%	N/A	81.4%				
California	7	D+3	Ami Bera	D	155,016	126,601	0	55.0%	45.0%	0.0%	10.1%	11.2%	-1.1%	91.0%				
California	8	R+9	Paul Cook	R	0	170,785	0	0.0%	100.0%	0.0%	-100.0%	-15.1%	N/A	73.3%				
California	9	D+8	Jerry McNerney	D	113,240	87,263	0	56.5%	43.5%	0.0%	13.0%	18.2%	-5.2%	82.4%				

It's also common for *less* good reasons

State	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q
State	CD#	2018 Cook PVI Score	2018 Winner	Party	Dem Votes	GOP Votes	Other Votes	Dem %	GOP %	Other %	Dem Margin	2016 Clinton Margin	Swing vs. 2016 Prez	Raw Votes vs. 2016	Final?	
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California 9 D+8 Jerry McNerney D 113,240 87,263 0 56.5% 43.5% 0.0% 13.0% 18.2% -5.2% 82.4% x																

More than one header row

Mixed data types in some columns

Color and typography used to encode variables and their values

Fix it **before** you import it

Prevention is better than cure!

An excellent article by Karl Broman and Kara Woo:

Broman KW, Woo KH (2018) "Data organization in spreadsheets." *The American Statistician* 78:2–10

The screenshot shows a digital journal article page. At the top left, it displays 'THE AMERICAN STATISTICIAN' and '2018, VOL. 72, NO. 1, 2–10'. Below this is the DOI: <https://doi.org/10.1080/00031305.2017.1375989>. On the right side, there's a logo for 'Taylor & Francis' and 'Taylor & Francis Group'. Below the header, the title 'Data Organization in Spreadsheets' is centered. Underneath the title, the authors are listed as 'Karl W. Broman^a and Kara H. Woo^b'. A note below the authors indicates: ^aDepartment of Biostatistics & Medical Informatics, University of Wisconsin-Madison, Madison, WI; ^bInformation School, University of Washington, Seattle, WA. To the right of the authors, there are two buttons: 'OPEN ACCESS' and 'Check for updates'. Further down the page, under the heading 'ABSTRACT', there is a detailed paragraph about the practical recommendations for organizing spreadsheet data. To the right of the abstract, under 'ARTICLE HISTORY', it says 'Received: June 2017' and 'Revised: August 2017'. Below that, under 'KEYWORDS', are the terms 'Data management; Data organization; Microsoft Excel; Spreadsheets'.

Key points from Broman & Woo

	A	B	C
1	Date	Assay date	Weight
2		12/9/05	54.9
3		12/9/05	45.3
4	12/6/2005	e	47
5		e	45.7
6		e	52.9
7		1/11/2006	46.1
8		1/11/2006	38.6

Use a consistent date format

Figure 1. A spreadsheet with inconsistent date formats. This spreadsheet does not adhere to our recommendations for consistency of date format.

ISO 8601

YYYY-MM-DD

The one true year-month-day format

Key points from Broman & Woo

A

	A	B	C
1	id	date	glucose
2	101	2015-06-14	149.3
3	102		95.3
4	103	2015-06-18	97.5
5	104		117.0
6	105		108.0
7	106	2015-06-20	149.0
8	107		169.4

B

	A	B	C	D	E	F	G	H	I
1		1 min				5 min			
2	strain	normal		mutant		normal		mutant	
3	A	147	139	166	179	334	354	451	474
4	B	246	240	178	172	514	611	412	447

No empty cells.

One row of headers only.

Key points from Broman & Woo

	A	B	C	D	E
1	strain	genotype	min	replicate	response
2	A	normal	1	1	147
3	A	normal	1	2	139
4	B	normal	1	1	246
5	B	normal	1	2	240
6	A	mutant	1	1	166
7	A	mutant	1	2	179
8	B	mutant	1	1	178
9	B	mutant	1	2	172
10	A	normal	5	1	334
11	A	normal	5	2	354
12	B	normal	5	1	514
13	B	normal	5	2	611
14	A	mutant	5	1	451
15	A	mutant	5	2	474
16	B	mutant	5	1	412
17	B	mutant	5	2	447

Tidied version.

Key points from Bromman & Woo

A

	A	B	C	D	E	F
1						
2		101	102	103	104	105
3	sex	Male	Female	Male	Male	Male
4						
5		101	102	103	104	105
6	glucose	134.1	120.0	124.8	83.1	105.2
7						
8		101	102	103	104	105
9	insulin	0.60	1.18	1.23	1.16	0.73

B

	A	B	C	D	E	F	G
1	1MIN						
2			Normal			Mutant	
3	B6	146.6	138.6	155.6	166	179.3	186.9
4	BTBR	245.7	240	243.1	177.8	171.6	188.1
5							
6	5MIN						
7			Normal			Mutant	
8	B6	333.6	353.6	408.8	450.6	474.4	423.8
9	BTBR	514.4	610.6	597.9	412.1	447.4	446.5

C

	A	B	C	D	E	F	G
1							
2	Date	11/3/14					
3	Days on diet	126					
4	Mouse #	43					
5	sex	f					
6	experiment	values			mean	SD	
7	control	0.186	0.191	1.081	0.49	0.52	
8	treatment A	7.414	1.468	2.254	3.71	3.23	
9	treatment B	9.811	9.259	11.296	10.12	1.05	
10							
11	fold change	values			mean	SD	
12	treatment A	15.26	3.02	4.64	7.64	6.65	
13	treatment B	20.19	19.05	23.24	20.83	2.17	

D

	A	B	C	D	E	F
1		GTT date	GTT weight	time	glucose mg/dl	insulin ng/ml
2	321	2/9/15	24.5	0	99.2	lo off curve
3				5	349.3	0.205
4				15	286.1	0.129
5				30	312	0.175
6				60	99.9	0.122
7				120	217.9	lo off curve
8	322	2/9/15	18.9	0	185.8	0.251
9				5	297.4	2.228
10				15	439	2.078
11				30	362.3	0.775
12				60	232.7	0.5
13				120	260.7	0.523
14	323	2/9/15	24.7	0	198.5	0.151
15				5	530.6	off curve lo

Rectangle your data.

Key points from Broman & Woo

A

	A	B	C
1	id	GTT date	GTT weight
2	321	2/9/15	24.5
3	322	2/9/15	18.9
4	323	2/9/15	24.7

B

	A	B	C	D	E
1	id	GTT time	glucose mg/dl	insulin ng/ml	note
2	321	0	99.2	NA	insulin below curve
3	321	5	349.3	0.205	
4	321	15	286.1	0.129	
5	321	30	312	0.175	
6	321	60	99.9	0.122	
7	321	120	217.9	NA	insulin below curve
8	322	0	185.8	0.251	
9	322	5	297.4	2.228	
10	322	15	439	2.078	
11	322	30	362.3	0.775	
12	322	60	232.7	0.5	
13	322	120	260.7	0.523	
14	323	0	198.5	0.151	
15	323	5	530.6	NA	insulin below curve

Use more than one table if needed. We can join them later.

Key points from Broman & Woo

	A	B	C	D	E	F	G	H	I	J	K
1			week 4			week 6			week 8		
2	Mouse ID	SEX	date	weight	glucose	date	weight	glucose	date	weight	glucose
3	3005	M	3/30/2007	19.3	635	4/11/2007	31	460.7	4/27/2007	39.6	530.2
4	3017	M	10/6/2006	25.9	202.4	10/19/2006	45.1	384.7	11/3/2006	57.2	458.7
5	3434	F	11/22/2006	26.6	238.9	12/6/2006	45.9	378	12/22/2006	56.2	409.8
6	3449	M	1/5/2007	27.5	121	1/19/2007	42.9	191.3	2/2/2007	56.7	182.5
7	3499	F	1/5/2007	19.8	220.2	1/19/2007	36.6	556.9	2/2/2007	43.6	446

Needs a single header row.

Needs a consistent naming scheme.

Key points from Broman & Woo

	A	B	C	D	E	F
1	mouse_id	sex	week	date	glucose	weight
2	3005	M	4	3/30/2007	19.3	635
3	3005	M	6	4/11/2007	31	460.7
4	3005	M	8	4/27/2007	39.6	530.2
5	3017	M	4	10/6/2006	25.9	202.4
6	3017	M	6	10/19/2006	45.1	384.7
7	3017	M	8	11/3/2006	57.2	458.7
8	3434	F	4	11/22/2006	26.6	238.9
9	3434	F	6	12/6/2006	45.9	378
10	3434	F	8	12/22/2006	56.2	409.8
11	3449	M	4	1/5/2007	27.5	121
12	3449	M	6	1/19/2007	42.9	191.3
13	3449	M	8	2/2/2007	56.7	182.5
14	3499	F	4	1/5/2007	19.8	220.2
15	3499	F	6	1/19/2007	36.6	556.9
16	3499	F	8	2/2/2007	43.6	446

Tidied version.

The most common `tidyverse` operation

Pivoting:

```
edu  
## # A tibble: 366 × 11  
##   age   sex   year total elem4 elem8   hs3   hs4 coll3 coll4 median  
##   <chr> <chr> <int> <int> <int> <dbl> <dbl> <dbl> <dbl> <dbl>  
## 1 25-34 Male   2016 21845   116   468  1427  6386  6015  7432    NA  
## 2 25-34 Male   2015 21427   166   488  1584  6198  5920  7071    NA  
## 3 25-34 Male   2014 21217   151   512  1611  6323  5910  6710    NA  
## 4 25-34 Male   2013 20816   161   582  1747  6058  5749  6519    NA  
## 5 25-34 Male   2012 20464   161   579  1707  6127  5619  6270    NA  
## 6 25-34 Male   2011 20985   190   657  1791  6444  5750  6151    NA  
## 7 25-34 Male   2010 20689   186   641  1866  6458  5587  5951    NA  
## 8 25-34 Male   2009 20440   184   695  1806  6495  5508  5752    NA  
## 9 25-34 Male   2008 20210   172   714  1874  6356  5277  5816    NA  
## 10 25-34 Male  2007 20024   246   757  1930  6361  5137  5593   NA  
## # i 356 more rows
```

The "Level of Schooling Attained" measure is spread across the columns, from `elem4` to `coll4`.

This is fine for a compact table, but for us it should be a single measure, say, "education".

From wide to long with pivot_longer()

We're going to put the columns elem4:coll4 into a new column, creating a new categorical measure named **education**. The numbers currently under each column will become a new **value** column corresponding to that level of education.

```
edu %>  
pivot_longer(elem4:coll4, names_to = "education")  
  
## # A tibble: 2,196 × 7  
##   age   sex   year total median education value  
##   <chr> <chr> <int> <int>  <dbl> <chr>     <dbl>  
## 1 25-34 Male   2016 21845     NA elem4      116  
## 2 25-34 Male   2016 21845     NA elem8      468  
## 3 25-34 Male   2016 21845     NA hs3       1427  
## 4 25-34 Male   2016 21845     NA hs4       6386  
## 5 25-34 Male   2016 21845     NA coll3     6015  
## 6 25-34 Male   2016 21845     NA coll4     7432  
## 7 25-34 Male   2015 21427     NA elem4      166  
## 8 25-34 Male   2015 21427     NA elem8      488  
## 9 25-34 Male   2015 21427     NA hs3       1584  
## 10 25-34 Male  2015 21427     NA hs4       6198  
## # i 2,186 more rows
```

From wide to long with pivot_longer()

We can name the value column to whatever we like. Here it's a number of people.

```
edu >
pivot_longer(elem4:coll4, names_to = "education", values_to = "n")

## # A tibble: 2,196 × 7
##   age   sex   year total median education     n
##   <chr> <chr> <int> <int>  <dbl> <chr>     <dbl>
## 1 25-34 Male   2016 21845     NA elem4      116
## 2 25-34 Male   2016 21845     NA elem8      468
## 3 25-34 Male   2016 21845     NA hs3       1427
## 4 25-34 Male   2016 21845     NA hs4       6386
## 5 25-34 Male   2016 21845     NA coll3     6015
## 6 25-34 Male   2016 21845     NA coll4     7432
## 7 25-34 Male   2015 21427     NA elem4      166
## 8 25-34 Male   2015 21427     NA elem8      488
## 9 25-34 Male   2015 21427     NA hs3       1584
## 10 25-34 Male  2015 21427     NA hs4       6198
## # i 2,186 more rows
```

Let's **recode()** it while we're here

```
edu ▷  
pivot_longer(elem4:coll4, names_to = "education", values_to = "n") ▷  
mutate(education = recode(education,  
                           elem4 = "Elementary 4", elem8 = "Elementary 8",  
                           hs3 = "High School 3", hs4 = "High School 4",  
                           coll3 = "College 3", coll4 = "College 4"))  
  
## # A tibble: 2,196 × 7  
##   age   sex   year total median education      n  
##   <chr> <chr> <int> <int>  <dbl> <chr>      <dbl>  
## 1 25-34 Male   2016 21845     NA Elementary 4    116  
## 2 25-34 Male   2016 21845     NA Elementary 8    468  
## 3 25-34 Male   2016 21845     NA High School 3  1427  
## 4 25-34 Male   2016 21845     NA High School 4  6386  
## 5 25-34 Male   2016 21845     NA College 3     6015  
## 6 25-34 Male   2016 21845     NA College 4     7432  
## 7 25-34 Male   2015 21427     NA Elementary 4    166  
## 8 25-34 Male   2015 21427     NA Elementary 8    488  
## 9 25-34 Male   2015 21427     NA High School 3  1584  
## 10 25-34 Male  2015 21427     NA High School 4  6198  
## # i 2,186 more rows
```

The argument order of **recode()** is inconsistent with other tidyverse functions and it may be superceded in the future.

pivot_longer() implies pivot_wider()

gapminder

```
## # A tibble: 1,704 × 6
##   country   continent year lifeExp      pop gdpPercap
##   <fct>     <fct>    <int>   <dbl>    <int>     <dbl>
## 1 Afghanistan Asia     1952     28.8  8425333     779.
## 2 Afghanistan Asia     1957     30.3  9240934     821.
## 3 Afghanistan Asia     1962     32.0  10267083    853.
## 4 Afghanistan Asia     1967     34.0  11537966    836.
## 5 Afghanistan Asia     1972     36.1  13079460    740.
## 6 Afghanistan Asia     1977     38.4  14880372    786.
## 7 Afghanistan Asia     1982     39.9  12881816    978.
## 8 Afghanistan Asia     1987     40.8  13867957    852.
## 9 Afghanistan Asia     1992     41.7  16317921    649.
## 10 Afghanistan Asia    1997     41.8  22227415    635.
## # i 1,694 more rows
```

pivot_longer() implies pivot_wider()

```
gapminder >
  select(country, continent, year, lifeExp) >
  pivot_wider(names_from = year, values_from = lifeExp)

## # A tibble: 142 × 14
##   country   continent `1952` `1957` `1962` `1967` `1972` `1977` `1982` `1987` 
##   <fct>     <fct>    <dbl>   <dbl>   <dbl>   <dbl>   <dbl>   <dbl>   <dbl> 
## 1 Afghanistan Asia      28.8    30.3   32.0   34.0   36.1   38.4   39.9   40.8 
## 2 Albania      Europe    55.2    59.3   64.8   66.2   67.7   68.9   70.4   72.0  
## 3 Algeria      Africa    43.1    45.7   48.3   51.4   54.5   58.0   61.4   65.8 
## 4 Angola       Africa    30.0    32.0   34.0   36.0   37.9   39.5   39.9   39.9 
## 5 Argentina    Americas   62.5    64.4   65.1   65.6   67.1   68.5   69.9   70.8 
## 6 Australia    Oceania   69.1    70.3   70.9   71.1   71.9   73.5   74.7   76.3 
## 7 Austria      Europe    66.8    67.5   69.5   70.1   70.6   72.2   73.2   74.9 
## 8 Bahrain      Asia      50.9    53.8   56.9   59.9   63.3   65.6   69.1   70.8 
## 9 Bangladesh   Asia      37.5    39.3   41.2   43.5   45.3   46.9   50.0   52.8 
## 10 Belgium     Europe    68.0    69.2   70.2   70.9   71.4   72.8   73.9   75.4 
## # i 132 more rows
## # i 4 more variables: `1992` <dbl>, `1997` <dbl>, `2002` <dbl>, `2007` <dbl>
```

What about widening *multiple* columns?

This is a pretty common problem.

Our first thought ("Just don't mention the other columns") isn't it:

```
gapminder >
  pivot_wider(names_from = year, values_from = lifeExp)

## # A tibble: 1,704 × 16
##   country continent   pop gdpPercap `1952` `1957` `1962` `1967` `1972` `1977` 
##   <fct>    <fct>     <int>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    
## 1 Afghani... Asia      8.43e6    779.    28.8     NA      NA      NA      NA      NA
## 2 Afghani... Asia      9.24e6    821.    NA       30.3     NA      NA      NA      NA
## 3 Afghani... Asia      1.03e7    853.    NA       NA      32.0     NA      NA      NA
## 4 Afghani... Asia      1.15e7    836.    NA       NA      NA      34.0     NA      NA
## 5 Afghani... Asia      1.31e7    740.    NA       NA      NA      NA      36.1     NA
## 6 Afghani... Asia      1.49e7    786.    NA       NA      NA      NA      NA      38.4
## 7 Afghani... Asia      1.29e7    978.    NA       NA      NA      NA      NA      NA
## 8 Afghani... Asia      1.39e7    852.    NA       NA      NA      NA      NA      NA
## 9 Afghani... Asia      1.63e7    649.    NA       NA      NA      NA      NA      NA
## 10 Afghani... Asia     2.22e7    635.    NA       NA      NA      NA      NA      NA
## # i 1,694 more rows
## # i 6 more variables: `1982` <dbl>, `1987` <dbl>, `1992` <dbl>, `1997` <dbl>,
## #   `2002` <dbl>, `2007` <dbl>
```

pop and gdpPercap are still long, and now our table is really sparse.

What about widening *multiple* columns?

We need to specify that we want values from more than one column.

```
gapminder >
  select(country, continent, year, lifeExp, gdpPercap) >
  pivot_wider(names_from = year, values_from = c(lifeExp, gdpPercap))

## # A tibble: 142 × 26
##   country    continent lifeExp_1952 lifeExp_1957 lifeExp_1962 lifeExp_1967
##   <fct>      <fct>        <dbl>       <dbl>       <dbl>       <dbl>
## 1 Afghanistan Asia         28.8       30.3       32.0       34.0
## 2 Albania     Europe       55.2       59.3       64.8       66.2
## 3 Algeria     Africa       43.1       45.7       48.3       51.4
## 4 Angola      Africa       30.0       32.0       34         36.0
## 5 Argentina   Americas     62.5       64.4       65.1       65.6
## 6 Australia   Oceania      69.1       70.3       70.9       71.1
## 7 Austria     Europe       66.8       67.5       69.5       70.1
## 8 Bahrain     Asia         50.9       53.8       56.9       59.9
## 9 Bangladesh  Asia         37.5       39.3       41.2       43.5
## 10 Belgium    Europe       68         69.2       70.2       70.9
## # i 132 more rows
## # i 20 more variables: lifeExp_1972 <dbl>, lifeExp_1977 <dbl>,
## #   lifeExp_1982 <dbl>, lifeExp_1987 <dbl>, lifeExp_1992 <dbl>,
## #   lifeExp_1997 <dbl>, lifeExp_2002 <dbl>, lifeExp_2007 <dbl>,
## #   gdpPercap_1952 <dbl>, gdpPercap_1957 <dbl>, gdpPercap_1962 <dbl>,
## #   gdpPercap_1967 <dbl>, gdpPercap_1972 <dbl>, gdpPercap_1977 <dbl>,
## #   gdpPercap_1982 <dbl>, gdpPercap_1987 <dbl>, gdpPercap_1992 <dbl>, ...
```

This will give us a very wide table, but it's what we wanted.

What about widening *multiple* columns?

Let's see that again. This time, let's say we want to calculate some within-stratum statistics as we do it.

```
# Some made-up data
dfstrat <- read_csv(here::here("data", "dfstrat.csv"))
dfstrat

## # A tibble: 1,000 × 5
##   stratum sex   race educ income
##   <dbl> <chr> <chr> <chr> <dbl>
## 1      6 F     W    HS     83.7
## 2      5 F     W    BA    128.
## 3      3 F     B    HS     66.3
## 4      3 F     W    HS     111.
## 5      6 M     W    BA    116.
## 6      7 M     B    HS    159.
## 7      8 M     W    BA    131.
## 8      3 M     W    BA    94.4
## 9      7 F     B    HS    146.
## 10     2 F     W    BA    88.8
## # i 990 more rows
```

Pivot wider while summarizing

```
dfstrat ← read_csv(here::here("data", "dfstrat.cs
```

Pivot wider while summarizing

```
dfstrat ← read_csv(here::here("data", "dfstrat.csv"))
dfstrat
## # A tibble: 1,000 × 5
##       stratum sex   race educ income
##       <dbl> <chr> <chr> <chr> <dbl>
## 1       6 F     W     HS    83.7
## 2       5 F     W     BA   128.
## 3       3 F     B     HS    66.3
## 4       3 F     W     HS    111.
## 5       6 M     W     BA   116.
## 6       7 M     B     HS   159.
## 7       8 M     W     BA   131.
## 8       3 M     W     BA   94.4
## 9       7 F     B     HS   146.
## 10      2 F     W     BA   88.8
## # i 990 more rows
```

Pivot wider while summarizing

```
dfstrat ← read_csv(here::here("data", "dfstrat.csv"))
dfstrat >
  group_by(sex, race, stratum, educ) ## # A tibble: 1,000 × 5
                                         ## # Groups:   sex, race, stratum, educ [64]
                                         ##   stratum sex   race educ income
                                         ##   <dbl> <chr> <chr> <chr> <dbl>
                                         ## 1       6 F     W    HS    83.7
                                         ## 2       5 F     W    BA   128.
                                         ## 3       3 F     B    HS    66.3
                                         ## 4       3 F     W    HS   111.
                                         ## 5       6 M     W    BA   116.
                                         ## 6       7 M     B    HS   159.
                                         ## 7       8 M     W    BA   131.
                                         ## 8       3 M     W    BA   94.4
                                         ## 9       7 F     B    HS   146.
                                         ## 10      2 F     W    BA   88.8
                                         ## # i 990 more rows
```

Pivot wider while summarizing

```
dfstrat ← read_csv(here::here("data", "dfstrat.csv"))
dfstrat >
  group_by(sex, race, stratum, educ) >
  summarize(mean_inc = mean(income),
            n = n())
## # A tibble: 64 × 6
## # Groups:   sex, race, stratum [32]
##       sex   race stratum educ mean_inc     n
##       <chr> <chr>    <dbl> <chr>      <dbl> <int>
## 1 F     B        1 BA      93.8     19
## 2 F     B        1 HS      99.3      6
## 3 F     B        2 BA      89.7     11
## 4 F     B        2 HS      93.0     16
## 5 F     B        3 BA     112.      13
## 6 F     B        3 HS      95.0     16
## 7 F     B        4 BA     108.      14
## 8 F     B        4 HS      96.1     15
## 9 F     B        5 BA      91.0     11
## 10 F    B        5 HS      92.6     15
## # i 54 more rows
```

Pivot wider while summarizing

```
dfstrat ← read_csv(here::here("data", "dfstrat.csv"))
dfstrat >
  group_by(sex, race, stratum, educ) >
  summarize(mean_inc = mean(income),
            n = n()) >
  pivot_wider(names_from = (educ),
              values_from = c(mean_inc, n))
```

```
## # A tibble: 32 × 7
## # Groups:   sex, race, stratum [32]
##       sex   race stratum mean_inc_BA mean_inc_HS n_BA n_HS
##       <chr> <chr>    <dbl>        <dbl>      <dbl> <int> <int>
## 1 F     B          1         93.8      99.3     19     6
## 2 F     B          2         89.7      93.0     11    16
## 3 F     B          3        112.      95.0     13    16
## 4 F     B          4        108.      96.1     14    15
## 5 F     B          5         91.0      92.6     11    15
## 6 F     B          6         93.0     116.     15    15
## 7 F     B          7        102.      121.     13    13
## 8 F     B          8        105.      88.3     14     8
## 9 F     W          1        92.6     110.     19    13
## 10 F    W          2        98.5     101.     15    19
## # i 22 more rows
```

Pivot wider while summarizing

```
dfstrat ← read_csv(here::here("data", "dfstrat.csv"))
dfstrat >#
  group_by(sex, race, stratum, educ) >
  summarize(mean_inc = mean(income),
            n = n()) >
  pivot_wider(names_from = (educ),
              values_from = c(mean_inc, n)) >
  ungroup()

## # A tibble: 32 × 7
##   sex   race stratum mean_inc_BA mean_inc_HS n_BA n_HS
##   <chr> <chr>    <dbl>        <dbl>     <dbl> <int> <int>
## 1 F     B          1         93.8      99.3    19     6
## 2 F     B          2         89.7      93.0    11    16
## 3 F     B          3        112.       95.0    13    16
## 4 F     B          4        108.       96.1    14    15
## 5 F     B          5        91.0      92.6    11    15
## 6 F     B          6        93.0      116.     15    15
## 7 F     B          7        102.      121.     13    13
## 8 F     B          8        105.       88.3    14     8
## 9 F     W          1        92.6      110.     19    13
## 10 F    W          2        98.5      101.     15    19
## # i 22 more rows
```

Pivot wider while summarizing

```
dfstrat ← read_csv(here::here("data", "dfstrat.csv"))
dfstrat > group_by(sex, race, stratum, educ) >
  summarize(mean_inc = mean(income),
            n = n()) >
  pivot_wider(names_from = (educ),
              values_from = c(mean_inc, n)) >
  ungroup()

## # A tibble: 32 × 7
##   sex   race stratum mean_inc_BA mean_inc_HS n_BA n_HS
##   <chr> <chr>   <dbl>        <dbl>     <dbl> <int> <int>
## 1 F     B         1          93.8      99.3    19     6
## 2 F     B         2          89.7      93.0    11    16
## 3 F     B         3         112.       95.0    13    16
## 4 F     B         4          108.      96.1    14    15
## 5 F     B         5          91.0      92.6    11    15
## 6 F     B         6          93.0      116.     15    15
## 7 F     B         7          102.      121.     13    13
## 8 F     B         8          105.      88.3    14     8
## 9 F     W         1          92.6      110.     19    13
## 10 F    W         2          98.5      101.     15    19
## # i 22 more rows
```

"Over-grouping" is one way to hang on to variables you want during the summary process.
All the action happens at the innermost group.

In this case, everything outside (or to the left of) stratum is untouched.

separate() and unite() columns

```
## tribble() lets you make tibbles by hand
df ← tribble(
  ~name, ~occupation,
  "Nero.Wolfe", "Private Detective",
  "Archie.Goodwin", "Personal Assistant",
  "Fritz.Brenner", "Cook and Butler",
  "Theodore.Horstmann", "Orchid Expert"
)
df
```

```
## # A tibble: 4 × 2
##   name           occupation
##   <chr>          <chr>
## 1 Nero.Wolfe   Private Detective
## 2 Archie.Goodwin Personal Assistant
## 3 Fritz.Brenner Cook and Butler
## 4 Theodore.Horstmann Orchid Expert
```

Separate and unite

```
df
```

```
## # A tibble: 4 × 2
##   name          occupation
##   <chr>         <chr>
## 1 Nero.Wolfe  Private Detective
## 2 Archie.Goodwin Personal Assistant
## 3 Fritz.Brenner Cook and Butler
## 4 Theodore.Horstmann Orchid Expert
```

Separate and unite

```
df %>  
  separate(name, into = c("first", "last"))  
  
## # A tibble: 4 × 3  
##   first     last    occupation  
##   <chr>     <chr>   <chr>  
## 1 Nero      Wolfe   Private Detective  
## 2 Archie    Goodwin Personal Assistant  
## 3 Fritz     Brenner  Cook and Butler  
## 4 Theodore  Horstmann Orchid Expert
```

Separate and unite

```
df %>  
  separate(name, into = c("first", "last")) %>  
  unite("full_name", first:last, sep = " ")  
  
## # A tibble: 4 × 2  
##   full_name      occupation  
##   <chr>          <chr>  
## 1 Nero Wolfe    Private Detective  
## 2 Archie Goodwin Personal Assistant  
## 3 Fritz Brenner  Cook and Butler  
## 4 Theodore Horstmann Orchid Expert
```

Separate and unite

```
df %>  
  separate(name, into = c("first", "last")) %>  
  unite("full_name", first:last, sep = " ") %>  
  unite("both_together", full_name:occupation,  
        sep = ", ", remove = FALSE)  
  
## # A tibble: 4 × 3  
##   both_together  
##   <chr>  
## 1 Nero Wolfe, Private Detective    Nero Wolfe  Private Detective  
## 2 Archie Goodwin, Personal Assistant Archie Goodwin Personal Assistant  
## 3 Fritz Brenner, Cook and Butler    Fritz Brenner Cook and Butler  
## 4 Theodore Horstmann, Orchid Expert Theodore Horstmann Orchid Expert
```

Separate and unite

```
df %>  
  separate(name, into = c("first", "last")) %>  
  unite("full_name", first:last, sep = " ") %>  
  unite("both_together", full_name:occupation,  
        sep = ", ", remove = FALSE)
```

```
## # A tibble: 4 × 3  
##   both_together  
##   <chr>  
## 1 Nero Wolfe, Private Detective    Nero Wolfe  Private Detective  
## 2 Archie Goodwin, Personal Assistant Archie Goodwin Personal Assistant  
## 3 Fritz Brenner, Cook and Butler   Fritz Brenner Cook and Butler  
## 4 Theodore Horstmann, Orchid Expert Theodore Horstmann Orchid Expert
```

Separate and unite

```
df
```

```
## # A tibble: 4 × 2
##   name          occupation
##   <chr>         <chr>
## 1 Nero.Wolfe  Private Detective
## 2 Archie.Goodwin Personal Assistant
## 3 Fritz.Brenner Cook and Butler
## 4 Theodore.Horstmann Orchid Expert
```

Separate and unite

```
df %>  
  separate(name, into = c("first", "last"))  
  
## # A tibble: 4 × 3  
##   first     last    occupation  
##   <chr>     <chr>   <chr>  
## 1 Nero      Wolfe   Private Detective  
## 2 Archie    Goodwin Personal Assistant  
## 3 Fritz     Brenner  Cook and Butler  
## 4 Theodore  Horstmann Orchid Expert
```

Separate and unite

```
df %>  
  separate(name, into = c("first", "last")) %>  
  unite("full_name", first:last)  
  
## # A tibble: 4 × 2  
##   full_name          occupation  
##   <chr>              <chr>  
## 1 Nero_Wolfe        Private Detective  
## 2 Archie_Goodwin    Personal Assistant  
## 3 Fritz_Brenner     Cook and Butler  
## 4 Theodore_Horstmann Orchid Expert
```

Separate and unite

```
df >  
  separate(name, into = c("first", "last")) >  
  unite("full_name", first:last) >  
  separate(full_name, into = c("first", "last"))  
## # A tibble: 4 × 3  
##   first     last    occupation  
##   <chr>     <chr>    <chr>  
## 1 Nero      Wolfe   Private Detective  
## 2 Archie    Goodwin Personal Assistant  
## 3 Fritz     Brenner  Cook and Butler  
## 4 Theodore  Horstmann Orchid Expert
```

Separate and unite

```
df >  
separate(name, into = c("first", "last")) >  
unite("full_name", first:last) >  
separate(full_name, into = c("first", "last"))  
## # A tibble: 4 × 3  
##   first     last   occupation  
##   <chr>     <chr>   <chr>  
## 1 Nero      Wolfe   Private Detective  
## 2 Archie    Goodwin Personal Assistant  
## 3 Fritz     Brenner  Cook and Butler  
## 4 Theodore  Horstmann Orchid Expert
```

The underscore, `_`, is the default uniting character.

Separate and unite

```
gss_sm  
## # A tibble: 2,867 × 32  
##   year     id ballot      age child_s sibs degree race sex  
##   <dbl> <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct>  
## 1 2016     1 1           47     3 2    Bach... White Male  
## 2 2016     2 2           61     0 3    High ... White Male  
## 3 2016     3 3           72     2 3    Bach... White Male  
## 4 2016     4 1           43     4 3    High ... White Fema  
## 5 2016     5 3           55     2 2    Gradu... White Fema  
## 6 2016     6 2           53     2 2    Junio... White Fema  
## 7 2016     7 1           50     2 2    High ... White Male  
## 8 2016     8 3           23     3 6    High ... Other Fema  
## 9 2016     9 1           45     3 5    High ... Black Male  
## 10 2016    10 3          71     4 1   Junio... White Male  
## # i 2,857 more rows  
## # i 21 more variables: relig <fct>, marital <fct>, padeg <fct>,  
## #   partyid <fct>, polviews <fct>, happy <fct>, partners <fct>,  
## #   zodiac <fct>, pres12 <labelled>, wtssall <dbl>, income_rc <  
## #   agegrp <fct>, ageq <fct>, siblings <fct>, kids <fct>, relig  
## #   bigregion <fct>, partners_rc <fct>, obama <dbl>
```

Separate and unite

```
gss_sm ▷  
  select(race, degree)  
  
## # A tibble: 2,867 × 2  
##   race    degree  
##   <fct> <fct>  
## 1 White Bachelor  
## 2 White High School  
## 3 White Bachelor  
## 4 White High School  
## 5 White Graduate  
## 6 White Junior College  
## 7 White High School  
## 8 Other High School  
## 9 Black High School  
## 10 White Junior College  
## # i 2,857 more rows
```

Separate and unite

```
gss_sm %>  
  select(race, degree) %>  
  mutate(racedeg = interaction(race, degree))  
  
## # A tibble: 2,867 × 3  
##   race    degree      racedeg  
##   <fct>  <fct>       <fct>  
## 1 White Bachelor  White.Bachelor  
## 2 White High School  White.High School  
## 3 White Bachelor  White.Bachelor  
## 4 White High School  White.High School  
## 5 White Graduate  White.Graduate  
## 6 White Junior College  White.Junior College  
## 7 White High School  White.High School  
## 8 Other High School  Other.High School  
## 9 Black High School  Black.High School  
## 10 White Junior College  White.Junior College  
## # i 2,857 more rows
```

Separate and unite

```
gss_sm %>  
  select(race, degree) %>  
  mutate(racedeg = interaction(race, degree)) %>  
  group_by(racedeg)  
  
## # A tibble: 2,867 × 3  
## # Groups:   racedeg [16]  
##   race   degree      racedeg  
##   <fct> <fct>       <fct>  
##   1 White Bachelor    White.Bachelor  
##   2 White High School White.High School  
##   3 White Bachelor    White.Bachelor  
##   4 White High School White.High School  
##   5 White Graduate    White.Graduate  
##   6 White Junior College White.Junior College  
##   7 White High School White.High School  
##   8 Other High School Other.High School  
##   9 Black High School Black.High School  
##  10 White Junior College White.Junior College  
## # i 2,857 more rows
```

Separate and unite

```
gss_sm %>  
  select(race, degree) %>  
  mutate(racedeg = interaction(race, degree)) %>  
  group_by(racedeg) %>  
  tally()  
  
## # A tibble: 16 × 2  
##   racedeg          n  
##   <fct>        <int>  
## 1 White.Lt High School    197  
## 2 Black.Lt High School     60  
## 3 Other.Lt High School     71  
## 4 White.High School    1057  
## 5 Black.High School     292  
## 6 Other.High School      112  
## 7 White.Junior College   166  
## 8 Black.Junior College    33  
## 9 Other.Junior College    17  
## 10 White.Bachelor       426  
## 11 Black.Bachelor        71  
## 12 Other.Bachelor        39  
## 13 White.Graduate        250  
## 14 Black.Graduate         31  
## 15 Other.Graduate        37  
## 16 <NA>                      8
```

Separate and unite

```
gss_sm ▷  
  select(race, degree) ▷  
  mutate(racedeg = interaction(race, degree)) ▷  
  group_by(racedeg) ▷  
  tally() ▷  
  separate(racedeg, sep = "\\. ", into = c("race", "degree"))  
  
## # A tibble: 16 × 3  
##   race   degree      n  
##   <chr>  <chr>     <int>  
## 1 White Lt High School    197  
## 2 Black Lt High School     60  
## 3 Other Lt High School     71  
## 4 White High School     1057  
## 5 Black High School      292  
## 6 Other High School       112  
## 7 White Junior College    166  
## 8 Black Junior College     33  
## 9 Other Junior College     17  
## 10 White Bachelor        426  
## 11 Black Bachelor         71  
## 12 Other Bachelor         39  
## 13 White Graduate        250  
## 14 Black Graduate         31  
## 15 Other Graduate         37  
## 16 <NA>    <NA>          8
```

This one is a bit trickier, and our first glimpse of a *regular expression*.

We have to tell **separate()** to split on the period, not the space.