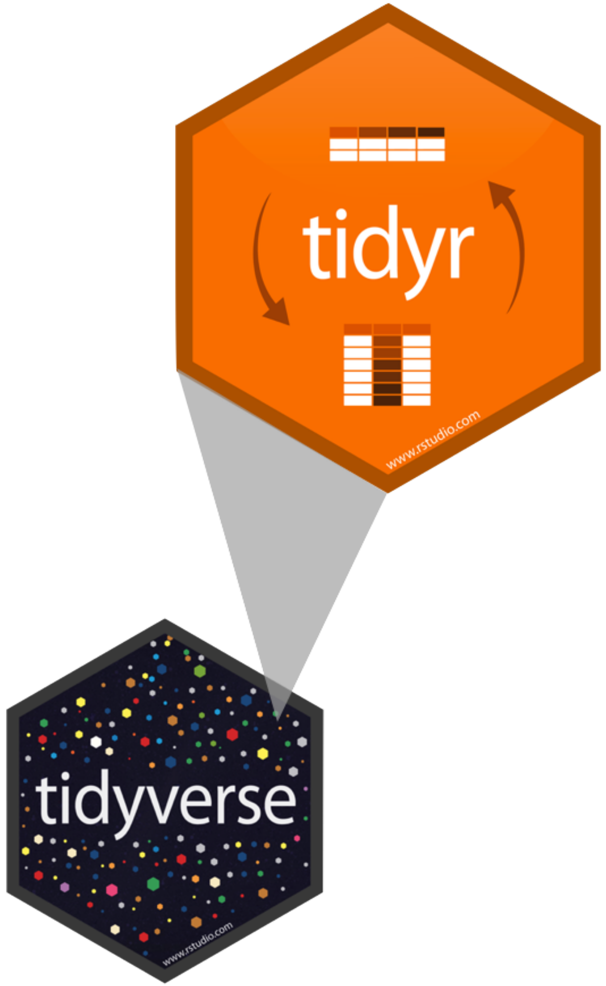
# Data tidying and reshaping 🧹

# Logistics

- Today:
  - 1/2 Lecture: review of tidying (pivot, rename), refining visualizations
    - Full lecture is on VoiceThread (see Moodle)
  - 1/2 Lab: continue lab05 team activity on vis refinement
    - Review merge conflict activity if you didn't yet see a conflict
    - More background info there now
- Return of the per-lecture nanofeedback quiz!
- Homework
  - **No HW 05**. Instead, review solutions and revise your past work
  - **Lab 5 replaces HW 05**
  - Homework and lab solutions posted today
- **Prep**: Modeling readings, VoiceThread

Reminder: Knit-Commit-Push *often*!

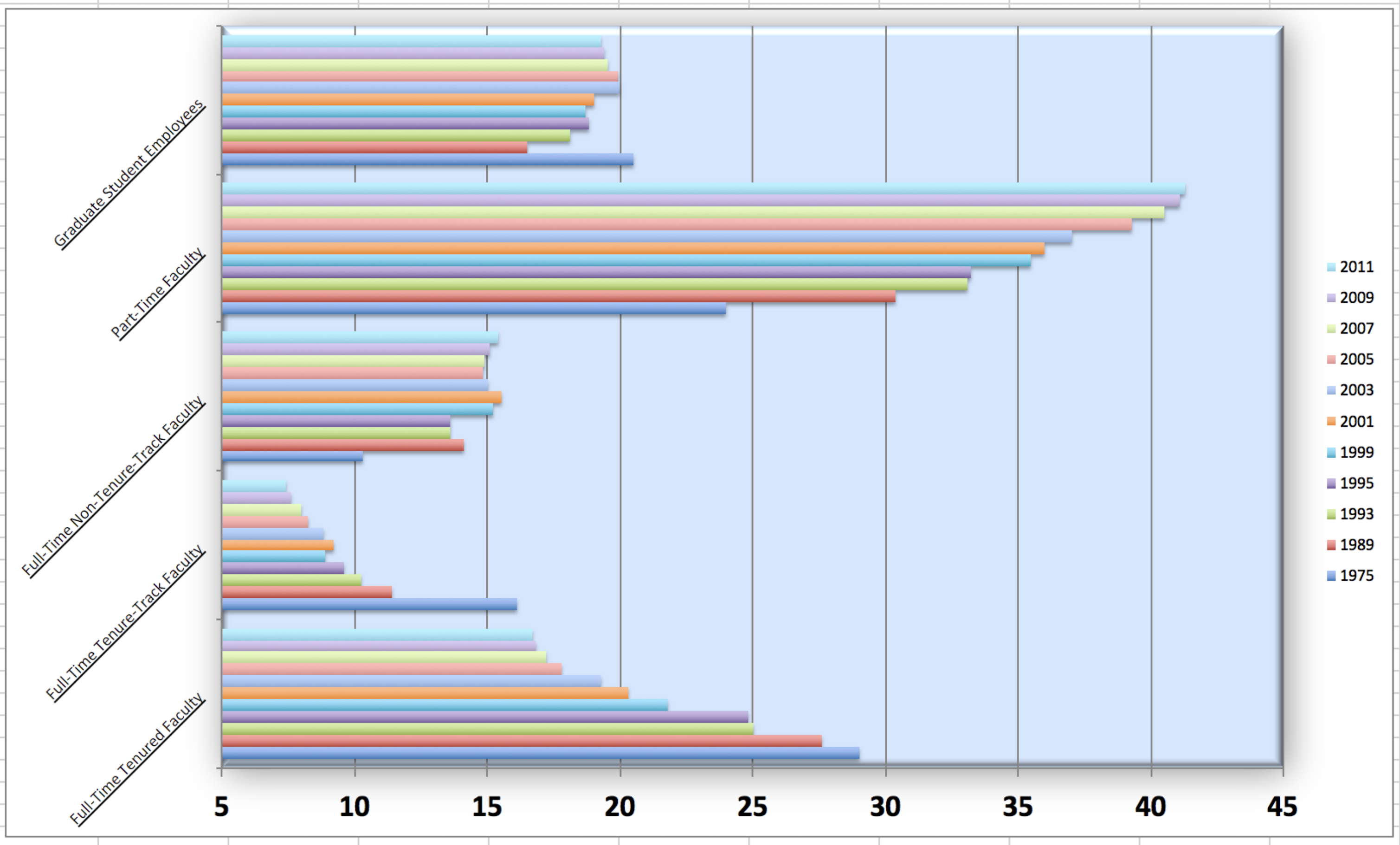
# A grammar of data tidying



The goal of tidyr is to help you create tidy data

# Instructional staff employment trends

The American Association of University Professors (AAUP) is a nonprofit membership association of faculty and other academic professionals. This report by the AAUP shows trends in instructional staff employees between 1975 and 2011, and contains an image very similar to the one given below.



# Data

Each row in this dataset represents a faculty type, and the columns are the years for which we have data. The values are percentage of hires of that type of faculty for each year.

```r
staff <- read_csv("data/instructional-staff.csv")
staff
```

```
## # A tibble: 5 x 12
##   faculty_type          `1975` `1989` `1993` `1995` `1999` `2001` `2003` `2005` `2007` `2009` `2011`
##   <chr>                  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
## 1 Full-Time Tenured Fa…   29     27.6   25      24.8   21.8   20.3   19.3   17.8   17.2   16.8   16.7
## 2 Full-Time Tenure-Tra…   16.1   11.4   10.2    9.6    8.9    9.2    8.8    8.2    8      7.6    7.4
## 3 Full-Time Non-Tenure…   10.3   14.1   13.6   13.6   15.2   15.5   15     14.8   14.9   15.1   15.4
## 4 Part-Time Faculty       24     30.4   33.1   33.2   35.5   36     37     39.3   40.5   41.1   41.3
## 5 Graduate Student Emp…   20.5   16.5   18.1   18.8   18.7   19     20     19.9   19.5   19.4   19.3
```

# Recreate the visualization

In order to recreate this visualization we need to first reshape the data to have one variable for faculty type and one variable for year. In other words, we will convert the data from the wide format to long format.

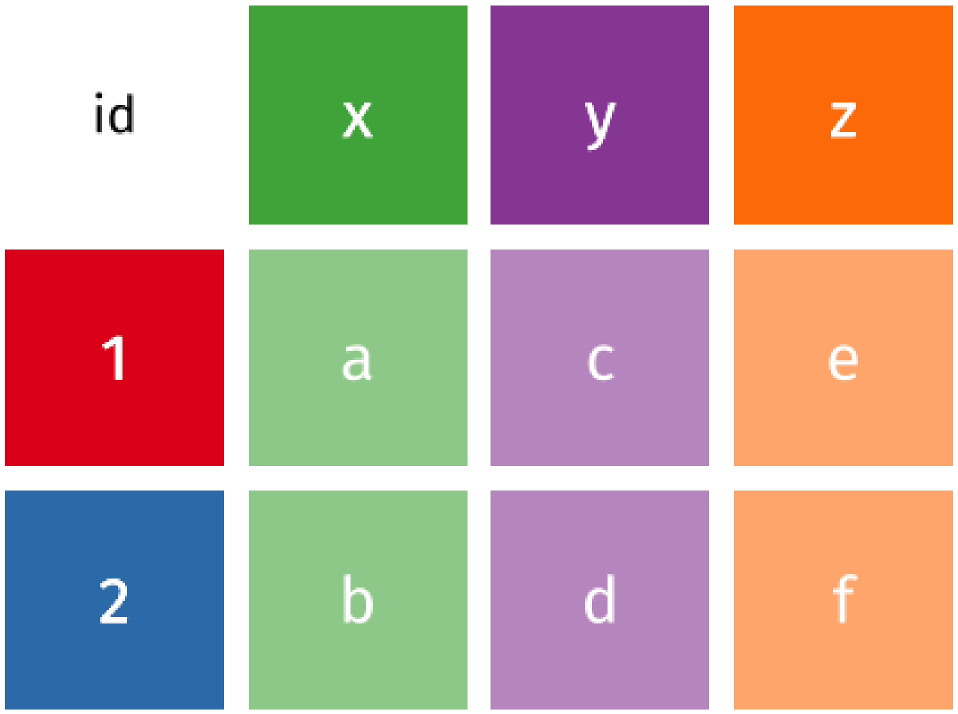
But before we do so...

If the long data will have a row for each year/faculty type combination, and there are 5 faculty types and 11 years of data, how many rows will the data have?

PIVOT!!!

# pivot_*() functions

wide



| id | x | y | z |
|---|---|---|---|
| 1 | a | c | e |
| 2 | b | d | f |

# pivot_longer()

```
pivot_longer(data, cols, names_to = "name", values_to = "value")
```

- The first argument is `data` as usual.

# `pivot_longer()`

```
pivot_longer(data, cols, names_to = "name", values_to = "value")
```

- The first argument is `data` as usual.
- The second argument, `cols`, is where you specify which columns to pivot into longer format -- in this case all columns except for the `faculty_type`

# `pivot_longer()`

```
pivot_longer(data, cols, names_to = "name", values_to = "value")
```

- The first argument is `data` as usual.
- The second argument, `cols`, is where you specify which columns to pivot into longer format -- in this case all columns except for the `faculty_type`
- The third argument, `names_to`, is a string specifying the name of the column to create from the data stored in the column names of data -- in this case `year`

# `pivot_longer()`

```
pivot_longer(data, cols, names_to = "name", values_to = "value")
```

- The first argument is `data` as usual.
- The second argument, `cols`, is where you specify which columns to pivot into longer format -- in this case all columns except for the `faculty_type`
- The third argument, `names_to`, is a string specifying the name of the column to create from the data stored in the column names of data -- in this case `year`
- The fourth argument, `values_to`, is a string specifying the name of the column to create from the data stored in cell values, in this case `percentage`

# Pivot staff data

```r
staff %>%
  pivot_longer(
    cols = -faculty_type,
    names_to = "year",
    values_to = "percentage"
    )
```

```
## # A tibble: 55 x 3
##   faculty_type              year  percentage
##   <chr>                     <chr>      <dbl>
## 1 Full-Time Tenured Faculty 1975        29  
## 2 Full-Time Tenured Faculty 1989        27.6
## 3 Full-Time Tenured Faculty 1993        25  
## 4 Full-Time Tenured Faculty 1995        24.8
## 5 Full-Time Tenured Faculty 1999        21.8
## 6 Full-Time Tenured Faculty 2001        20.3
## # … with 49 more rows
```

# Pivot staff data, and save result

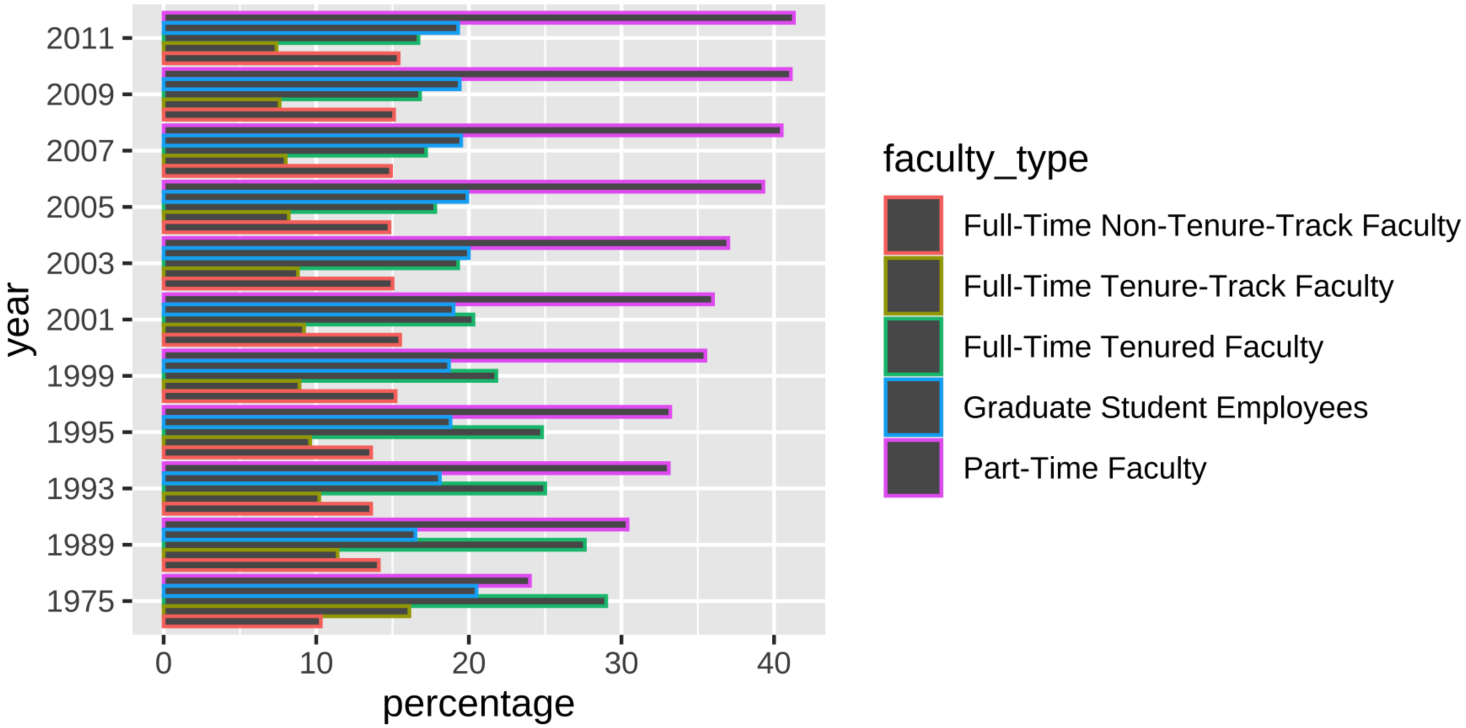
```r
staff_long <- staff %>%
  pivot_longer(
    cols = -faculty_type,
    names_to = "year",
    values_to = "percentage"
    )

staff_long
```

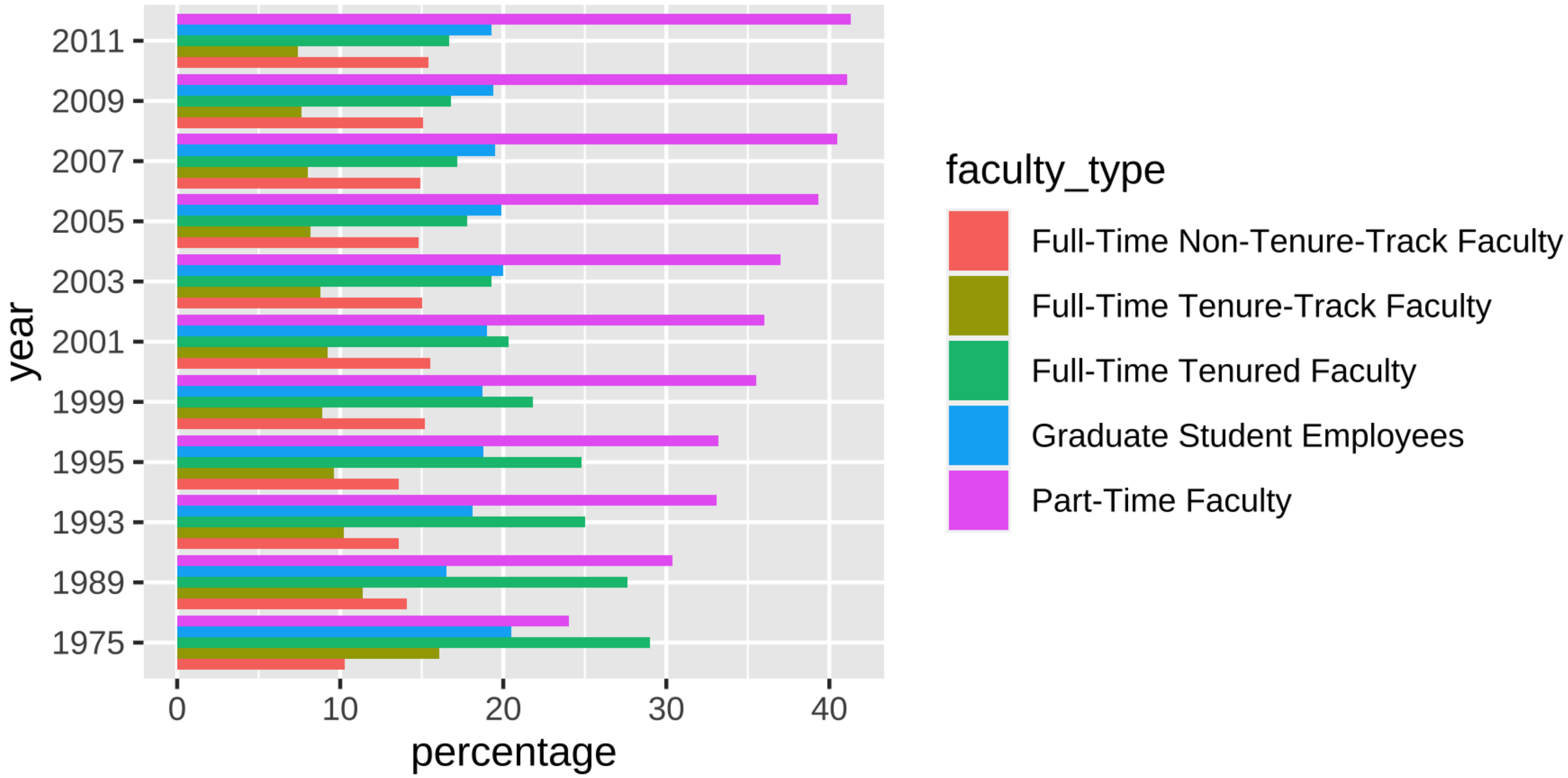
```
## # A tibble: 55 x 3
##   faculty_type              year  percentage
##   <chr>                     <chr>      <dbl>
## 1 Full-Time Tenured Faculty 1975        29  
## 2 Full-Time Tenured Faculty 1989        27.6
## 3 Full-Time Tenured Faculty 1993        25  
## 4 Full-Time Tenured Faculty 1995        24.8
## 5 Full-Time Tenured Faculty 1999        21.8
## 6 Full-Time Tenured Faculty 2001        20.3
## # … with 49 more rows
```

# This doesn't look quite right, how would you fix it?

```
staff_long %>%
  ggplot(aes(x = percentage, y = year, color = faculty_type)) +
  geom_col(position = "dodge")
```

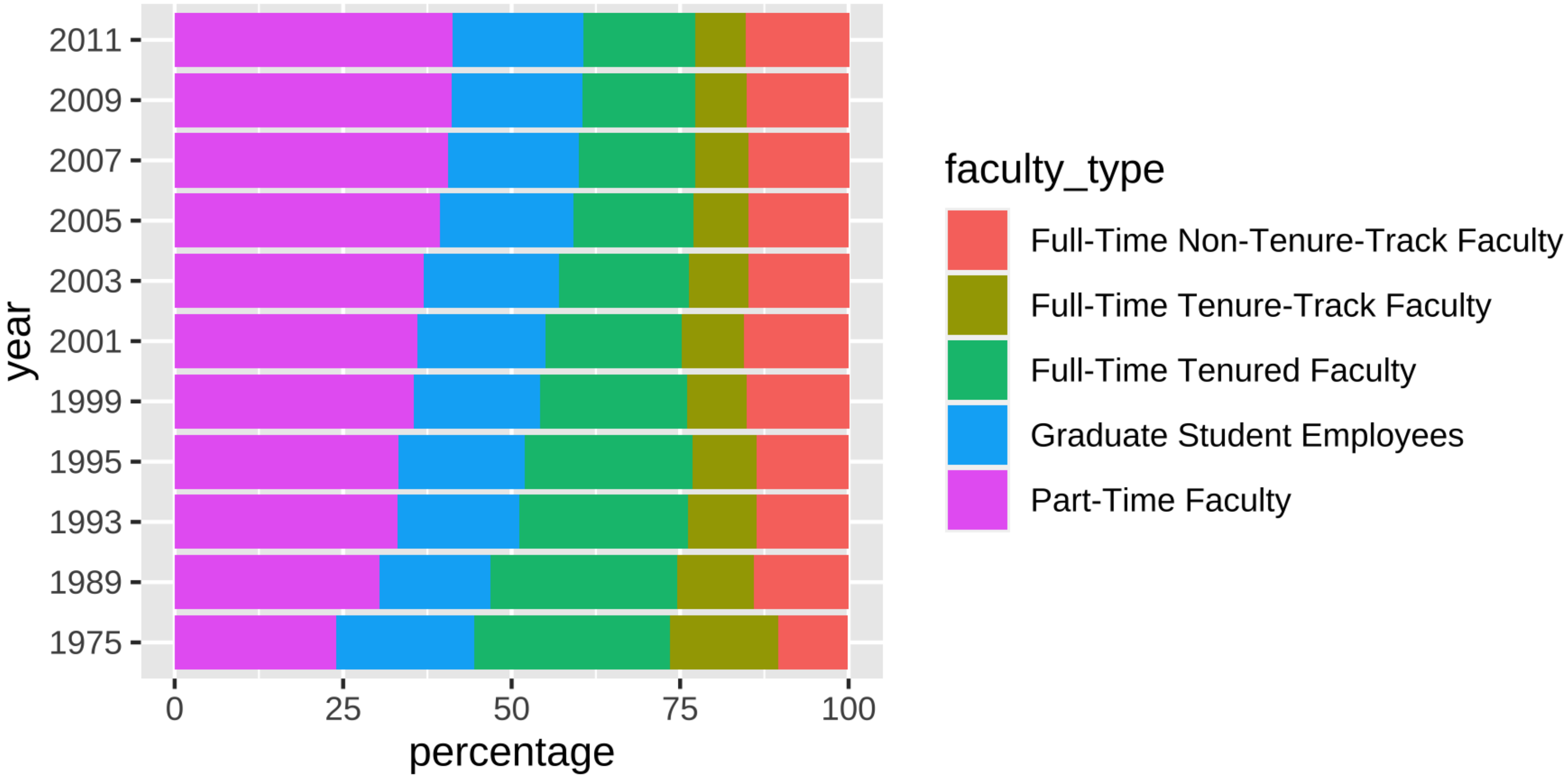


```
staff_long %>%
  ggplot(aes(x = percentage, y = year, fill = faculty_type)) +
  geom_col(position = "dodge")
```



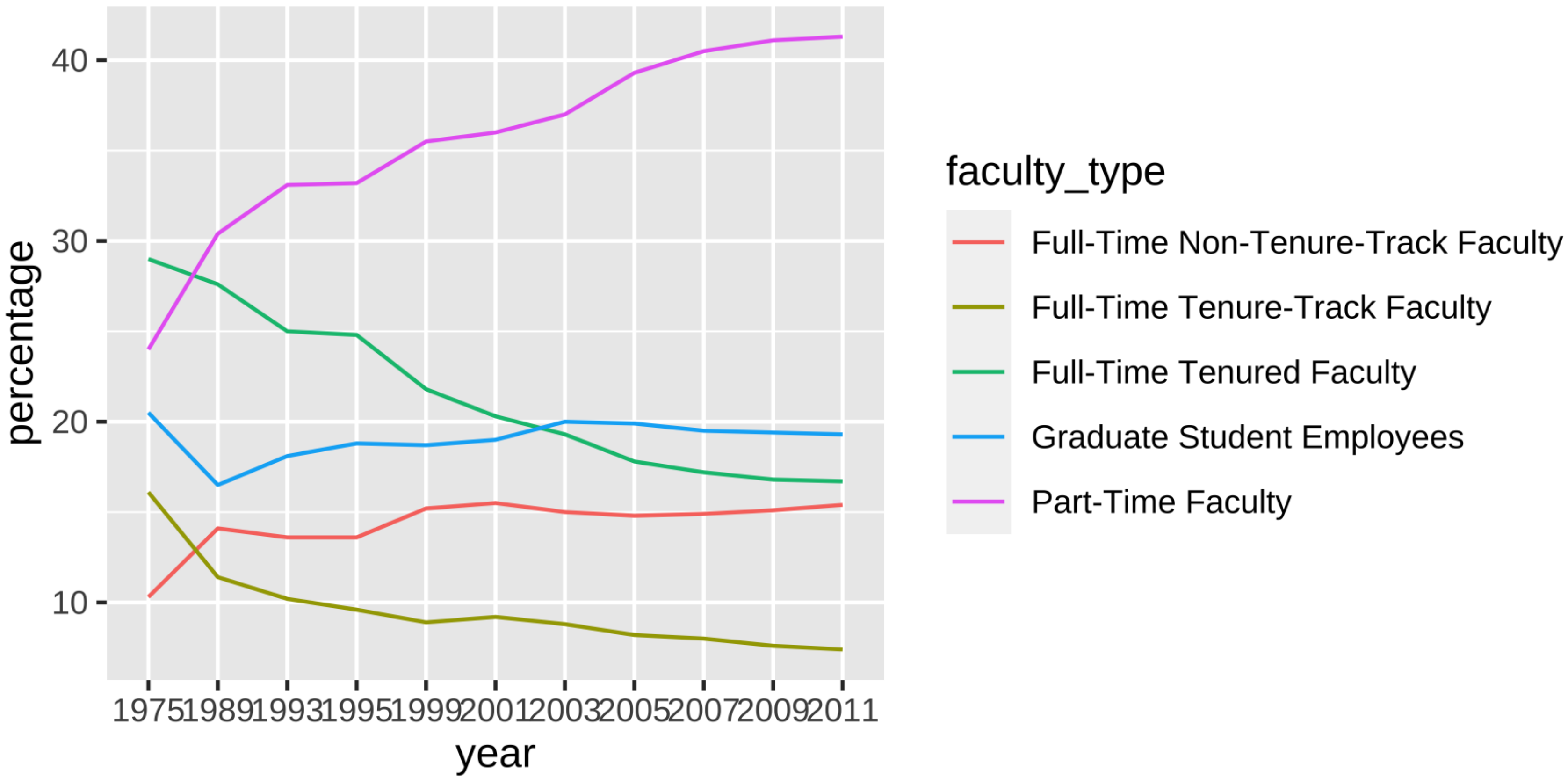
# Some improvement...

```
staff_long %>%
  ggplot(aes(x = percentage, y = year, fill = faculty_type)) +
  geom_col()
```

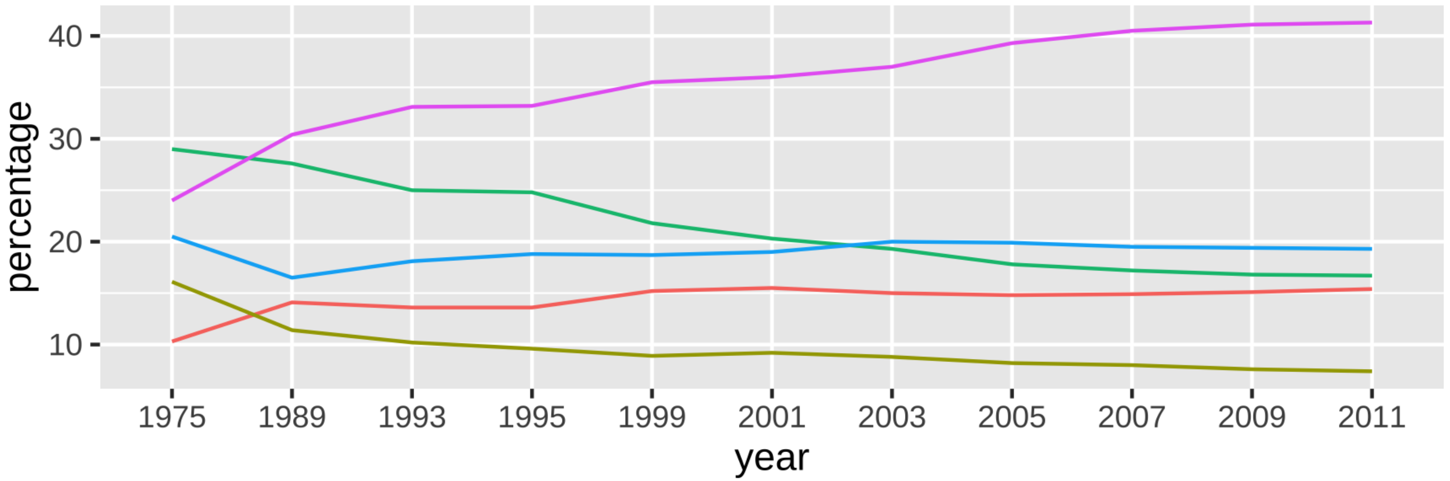


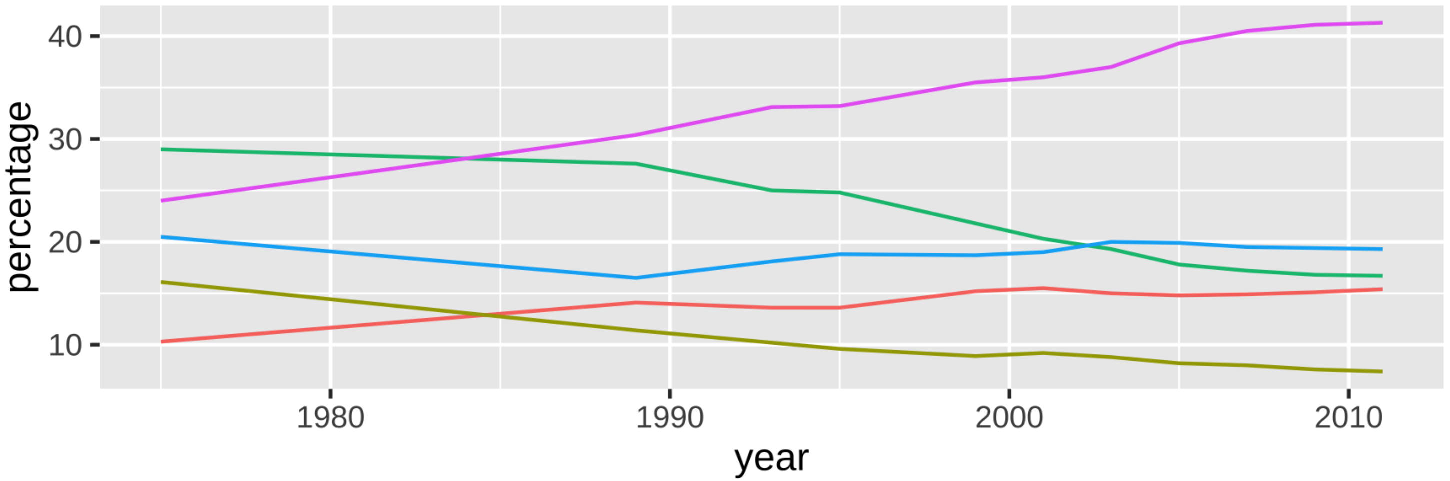
# More improvement

```
staff_long %>%
  ggplot(aes(x = year, y = percentage, group = faculty_type, color = faculty_type)) +
  geom_line()
```



# What is the difference between these two plots?

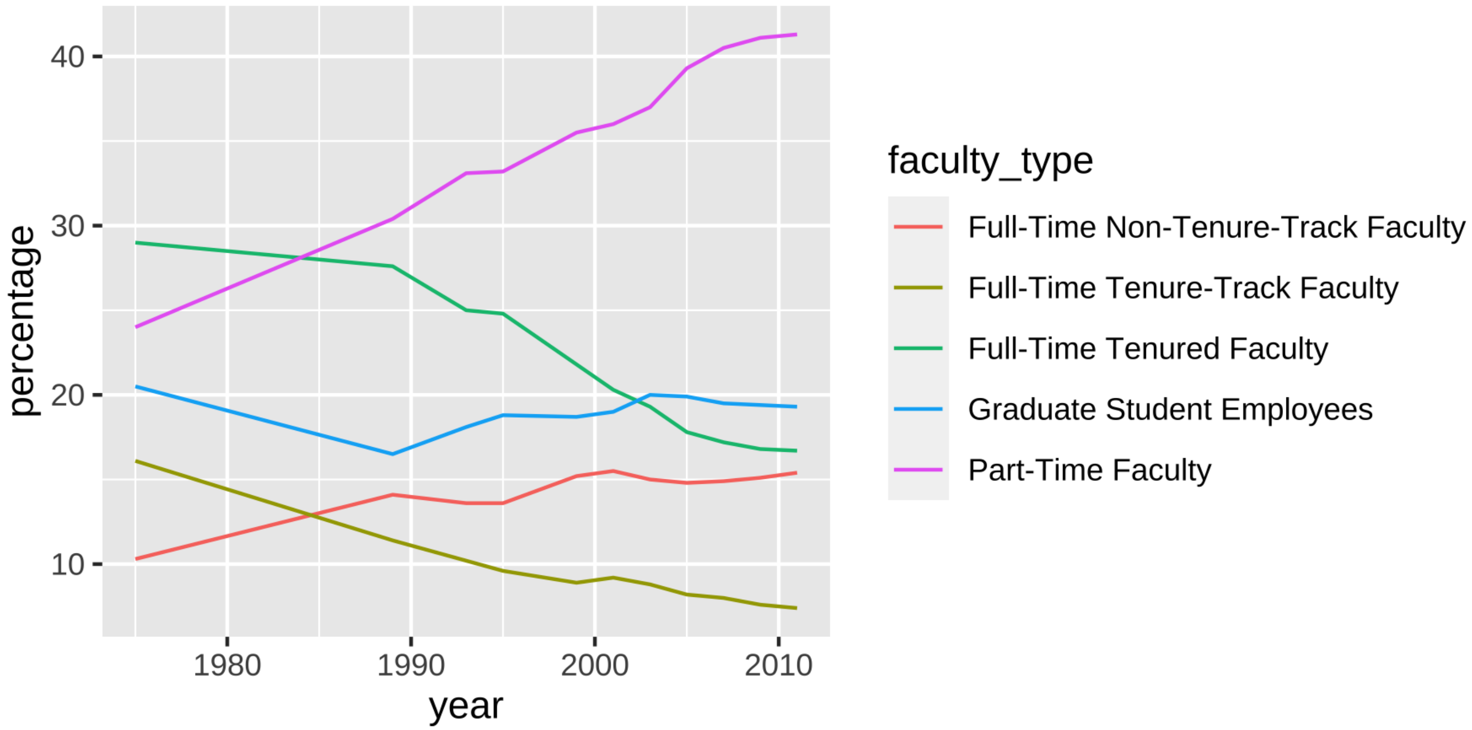




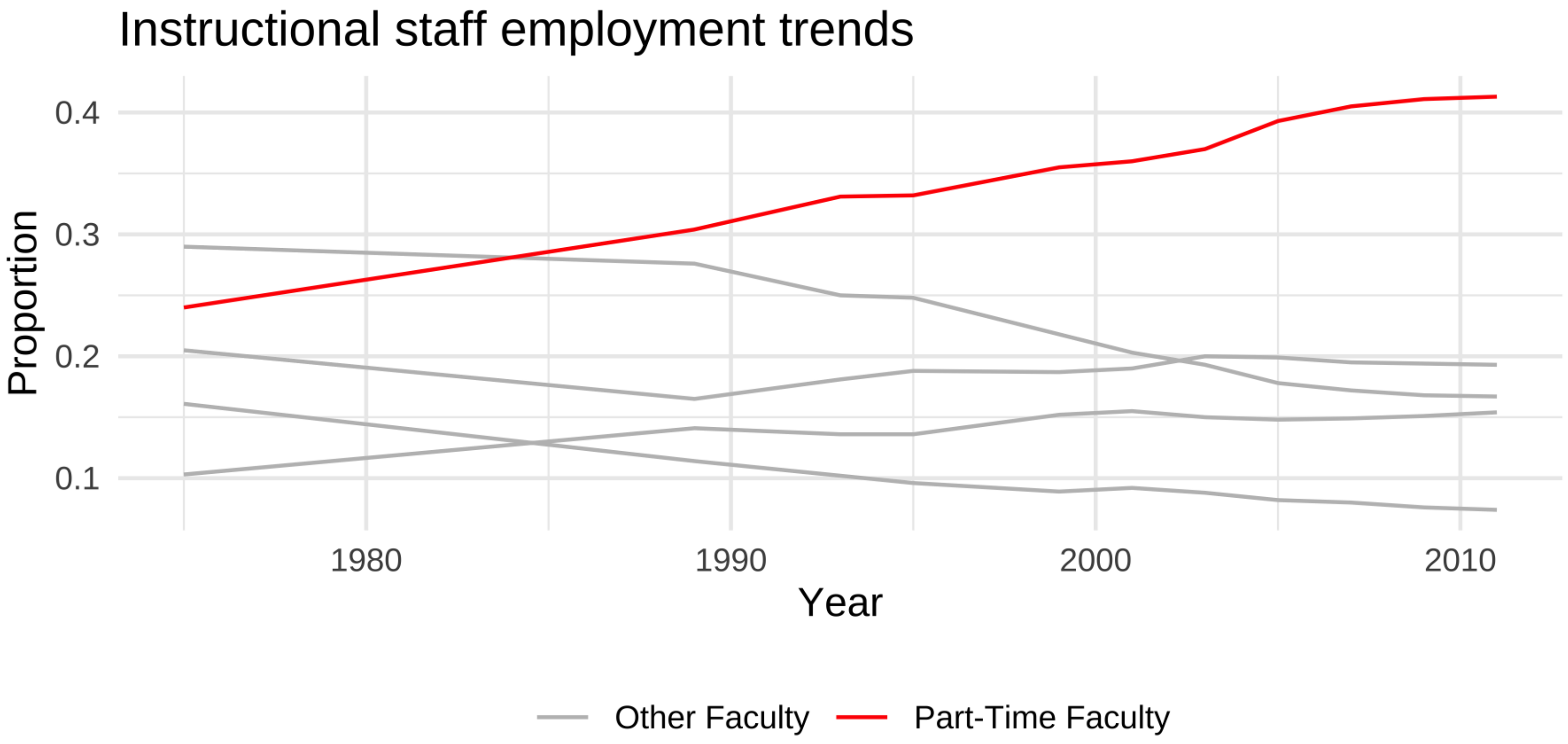
# Make year numeric again!

```
staff_long <- staff_long %>%
  mutate(year = as.numeric(year))

staff_long %>%
  ggplot(aes(x = year, y = percentage, group = faculty_type, color = faculty_type)) +
  geom_line()
```

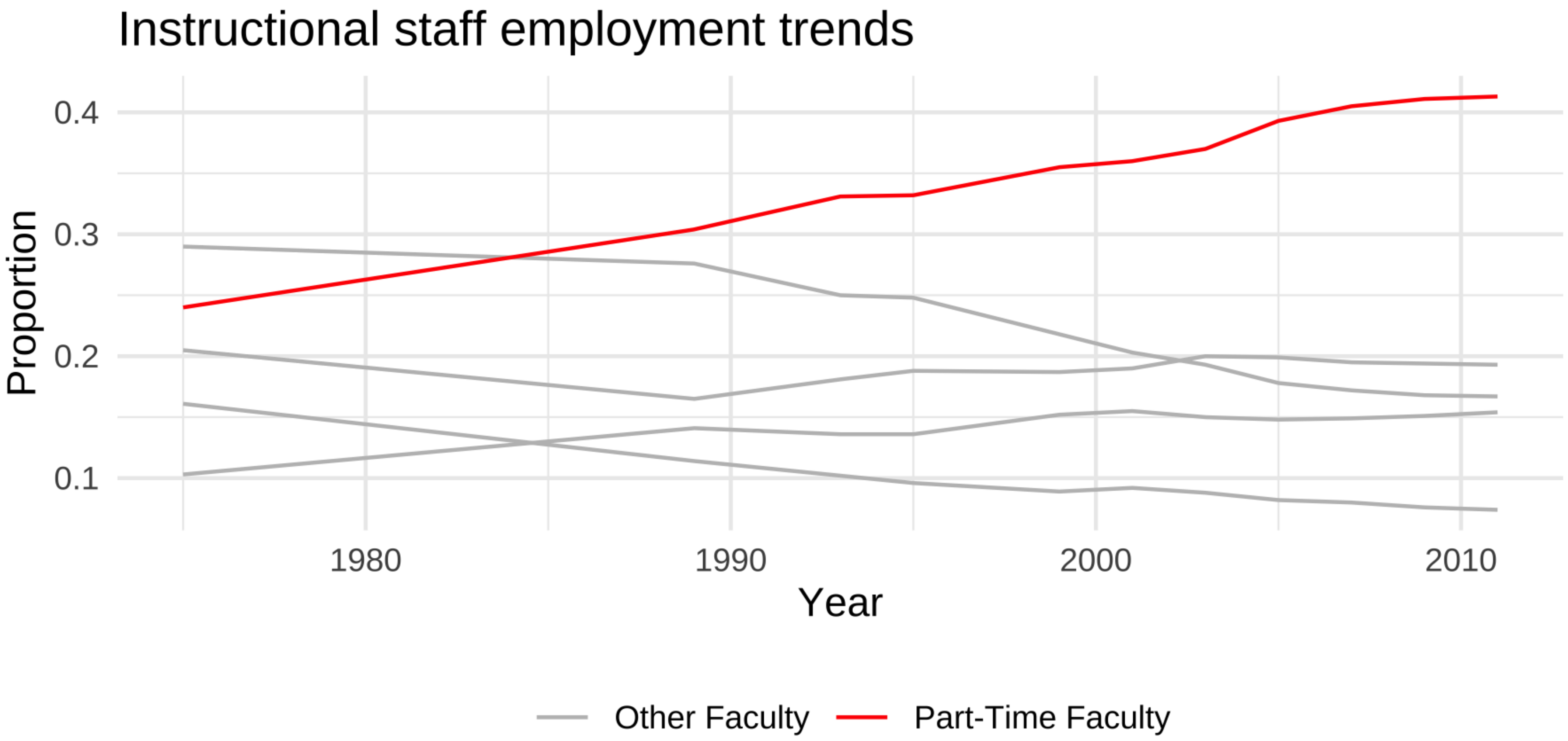


# How would you go about creating the following plot?



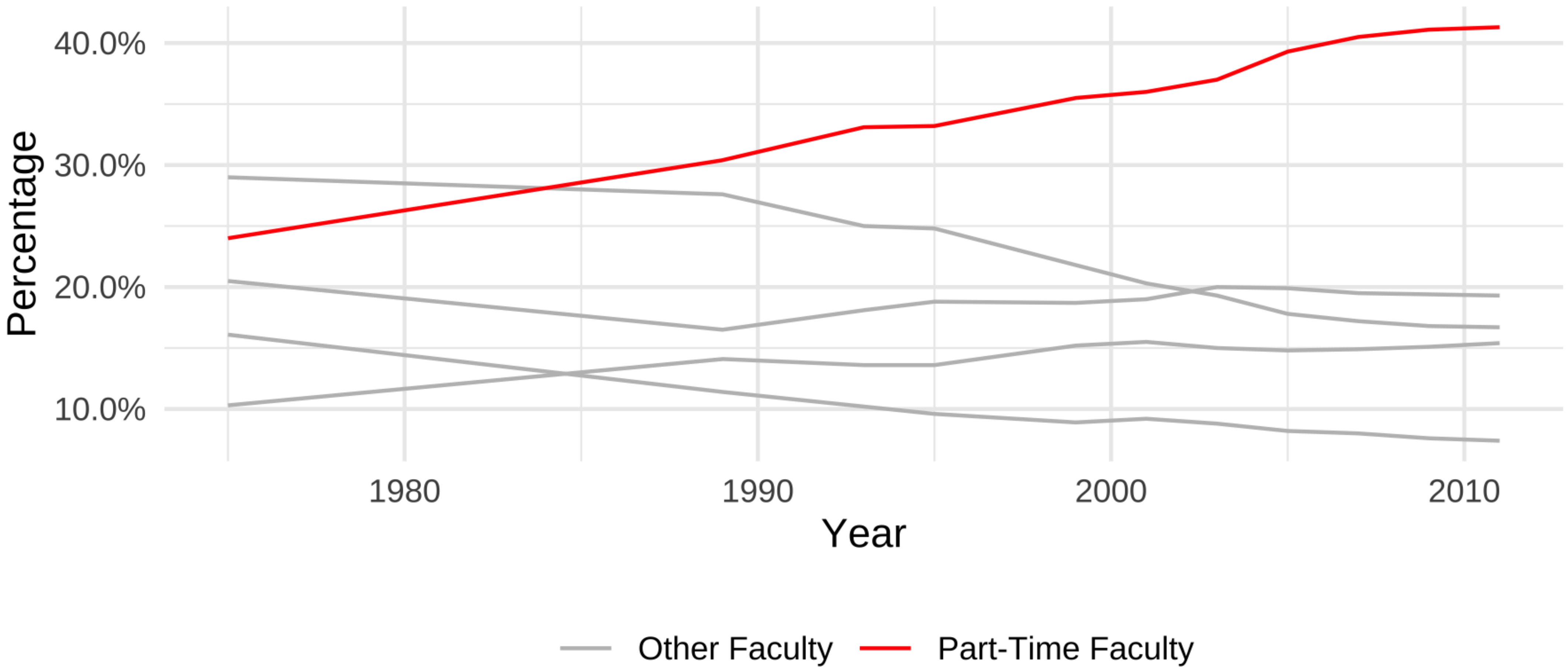
```r
staff_long %>%
  mutate(part_time = if_else(faculty_type == "Part-Time Faculty",
                             "Part-Time Faculty",
                             "Other Faculty")) %>%
  ggplot(aes(x = year, y = percentage/100,
             group = faculty_type,
             color = part_time)) +
  geom_line() +
  scale_color_manual(values = c("gray", "red")) +
  theme_minimal() +
  labs(
    title = "Instructional staff employment trends",
    x = "Year",
    y = "Proportion",
    color = ""
  ) +
  theme(legend.position = "bottom")
```

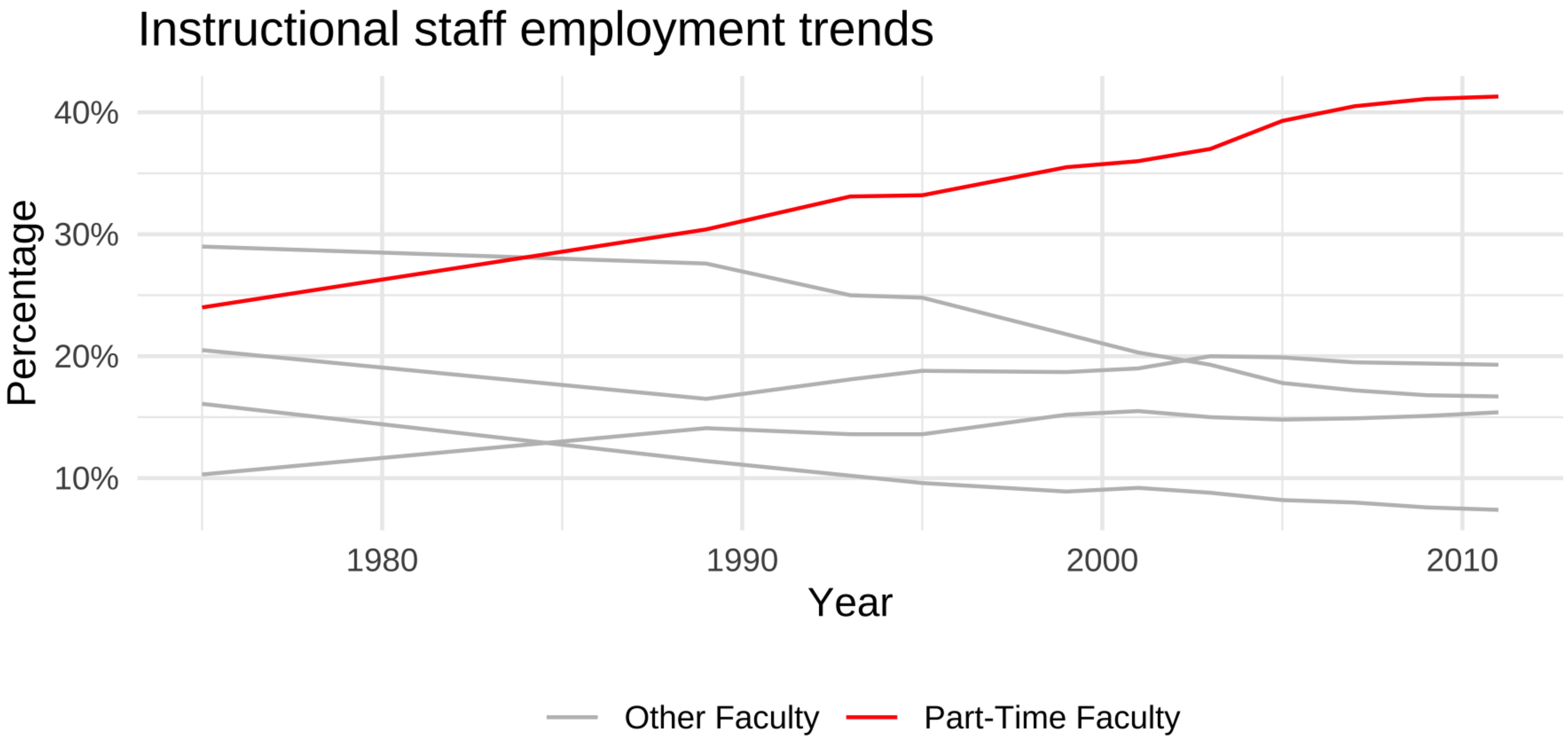
```
staff_long %>%
  mutate(part_time = if_else(faculty_type == "Part-Time Faculty",
                             "Part-Time Faculty",
                             "Other Faculty")) %>%
  ggplot(aes(x = year, y = percentage/100,
             group = faculty_type,
             color = part_time)) +
  geom_line() +
  scale_color_manual(values = c("gray", "red")) +
  theme_minimal() +
  labs(
    title = "Instructional staff employment trends",
    x = "Year",
    y = "Proportion",
    color = ""
  ) +
  theme(legend.position = "bottom")
```


Instructional staff employment trends
Proportion
0.4
0.3
0.2
0.1
1980
1990
2000
2010
Year
Other Faculty
Part-Time Faculty

```r
library(scales)
staff_long %>%
  mutate(part_time =
           if_else(faculty_type == "Part-Time Faculty",
                   "Part-Time Faculty", "Other Faculty")) %>%
  ggplot(aes(x = year, y = percentage/100, group = faculty_type,
             color = part_time)) +
  geom_line() +
  scale_color_manual(values = c("gray", "red")) +
  scale_y_continuous(labels = percent) +
  theme_minimal() +
  labs(
    title = "Instructional staff employment trends",
    x = "Year",
    y = "Percentage",
    color = ""
  ) +
  theme(legend.position = "bottom")
```

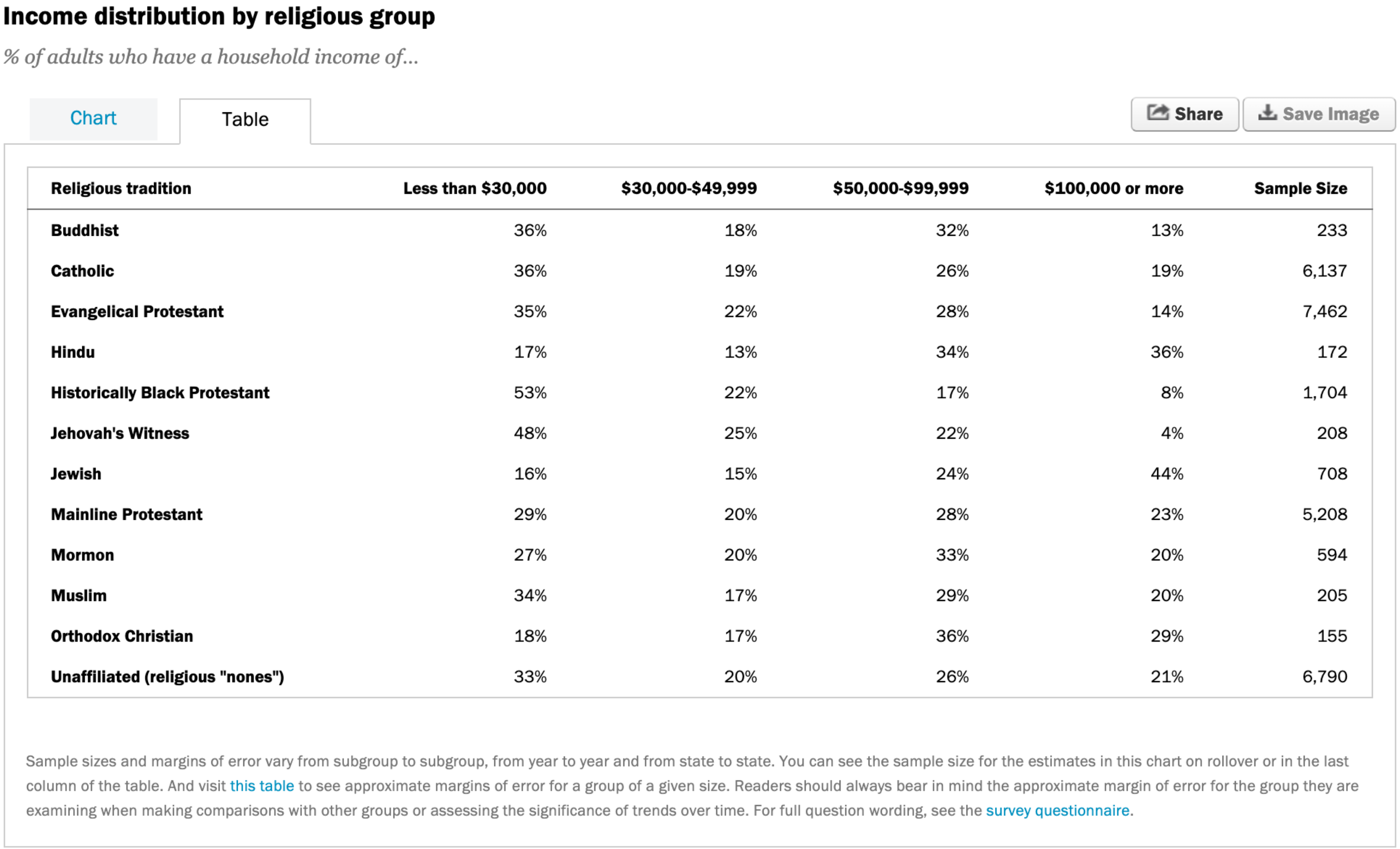
# Instructional staff employment trends




Instructional staff employment trends
40%
30%
20%
10%
Percentage
1980
1990
2000
2010
Year
Other Faculty
Part-Time Faculty

```r
library(scales)
staff_long %>%
  mutate(part_time =
           if_else(faculty_type == "Part-Time Faculty",
                   "Part-Time Faculty", "Other Faculty")) %>%
  ggplot(aes(x = year, y = percentage/100, group = faculty_type,
             color = part_time)) +
  geom_line() +
  scale_color_manual(values = c("gray", "red")) +
  scale_y_continuous(labels = percent_format(accuracy = 1)) +
  theme_minimal() +
  labs(
    title = "Instructional staff employment trends",
    x = "Year",
    y = "Percentage",
    color = ""
  ) +
  theme(legend.position = "bottom")
```

# Other common tidying moves



## Income distribution by religious group

*% of adults who have a household income of...*

| Religious tradition | Less than $30,000 | $30,000-$49,999 | $50,000-$99,999 | $100,000 or more | Sample Size |
|---|---|---|---|---|---|
| **Buddhist** | 36% | 18% | 32% | 13% | 233 |
| **Catholic** | 36% | 19% | 26% | 19% | 6,137 |
| **Evangelical Protestant** | 35% | 22% | 28% | 14% | 7,462 |
| **Hindu** | 17% | 13% | 34% | 36% | 172 |
| **Historically Black Protestant** | 53% | 22% | 17% | 8% | 1,704 |
| **Jehovah's Witness** | 48% | 25% | 22% | 4% | 208 |
| **Jewish** | 16% | 15% | 24% | 44% | 708 |
| **Mainline Protestant** | 29% | 20% | 28% | 23% | 5,208 |
| **Mormon** | 27% | 20% | 33% | 20% | 594 |
| **Muslim** | 34% | 17% | 29% | 20% | 205 |
| **Orthodox Christian** | 18% | 17% | 36% | 29% | 155 |
| **Unaffiliated (religious "nones")** | 33% | 20% | 26% | 21% | 6,790 |

Sample sizes and margins of error vary from subgroup to subgroup, from year to year and from state to state. You can see the sample size for the estimates in this chart on rollover or in the last column of the table. And visit this table to see approximate margins of error for a group of a given size. Readers should always bear in mind the approximate margin of error for the group they are examining when making comparisons with other groups or assessing the significance of trends over time. For full question wording, see the survey questionnaire.

Source: pewforum.org/religious-landscape-study/income-distribution, Retrieved 14 April, 2020

# Read data

```
library(readxl)
rel_inc <- read_excel("data/relig-income.xlsx") # directly from Excel!
```

```
## # A tibble: 12 x 6
##   `Religious trad… `Less than $30,… `$30,000-$49,99… `$50,000-$99,99… `$100,000 or mo… `Sample Size`
##   <chr>                       <dbl>            <dbl>            <dbl>            <dbl>         <dbl>
## 1 Buddhist                     0.36             0.18             0.32             0.13           233
## 2 Catholic                     0.36             0.19             0.26             0.19          6137
## 3 Evangelical Pro…             0.35             0.22             0.28             0.14          7462
## 4 Hindu                        0.17             0.13             0.34             0.36           172
## 5 Historically Bl…             0.53             0.22             0.17             0.08          1704
## 6 Jehovah's Witne…             0.48             0.25             0.22             0.04           208
## # … with 6 more rows
```

# Rename columns

```r
rel_inc %>%
  rename(
    religion = `Religious tradition`,
    n = `Sample Size`
  )
```

```
## # A tibble: 12 x 6
##   religion             `Less than $30,00… `$30,000-$49,999` `$50,000-$99,99… `$100,000 or mor…     n
##   <chr>                             <dbl>             <dbl>            <dbl>             <dbl> <dbl>
## 1 Buddhist                           0.36              0.18             0.32              0.13   233
## 2 Catholic                           0.36              0.19             0.26              0.19  6137
## 3 Evangelical Protest…               0.35              0.22             0.28              0.14  7462
## 4 Hindu                              0.17              0.13             0.34              0.36   172
## 5 Historically Black …               0.53              0.22             0.17              0.08  1704
## 6 Jehovah's Witness                  0.48              0.25             0.22              0.04   208
## # … with 6 more rows
```

# Rename columns

```
rel_inc %>%
  rename(
    religion = `Religious tradition`,
    n = `Sample Size`
  )
```

```
## # A tibble: 12 x 6
##   religion             `Less than $30,00… `$30,000-$49,999` `$50,000-$99,99… `$100,000 or mor…     n
##   <chr>                             <dbl>             <dbl>            <dbl>             <dbl> <dbl>
## 1 Buddhist                           0.36              0.18             0.32              0.13   233
## 2 Catholic                           0.36              0.19             0.26              0.19  6137
## 3 Evangelical Protest…               0.35              0.22             0.28              0.14  7462
## 4 Hindu                              0.17              0.13             0.34              0.36   172
## 5 Historically Black …               0.53              0.22             0.17              0.08  1704
## 6 Jehovah's Witness                  0.48              0.25             0.22              0.04   208
## # … with 6 more rows
```

If we want a new variable called `income` with levels such as "Less than $30,000", "$30,000-$49,999", ... etc. which function should we use?

# Pivot longer

```
rel_inc %>%
  rename(
    religion = `Religious tradition`,
    n = `Sample Size`
  ) %>%
  pivot_longer(
    cols = -c(religion, n),   # all but religion and n
    names_to = "income",
    values_to = "proportion"
  )
```

```
## # A tibble: 48 x 4
##   religion     n income             proportion
##   <chr>    <dbl> <chr>                   <dbl>
## 1 Buddhist   233 Less than $30,000        0.36
## 2 Buddhist   233 $30,000-$49,999          0.18
## 3 Buddhist   233 $50,000-$99,999          0.32
## 4 Buddhist   233 $100,000 or more         0.13
## 5 Catholic  6137 Less than $30,000        0.36
## 6 Catholic  6137 $30,000-$49,999          0.19
## # … with 42 more rows
```

# Calculate frequencies

```r
rel_inc %>%
  rename(
    religion = `Religious tradition`,
    n = `Sample Size`
  ) %>%
  pivot_longer(
    cols = -c(religion, n),
    names_to = "income",
    values_to = "proportion"
  ) %>%
  mutate(frequency = round(proportion * n))
```

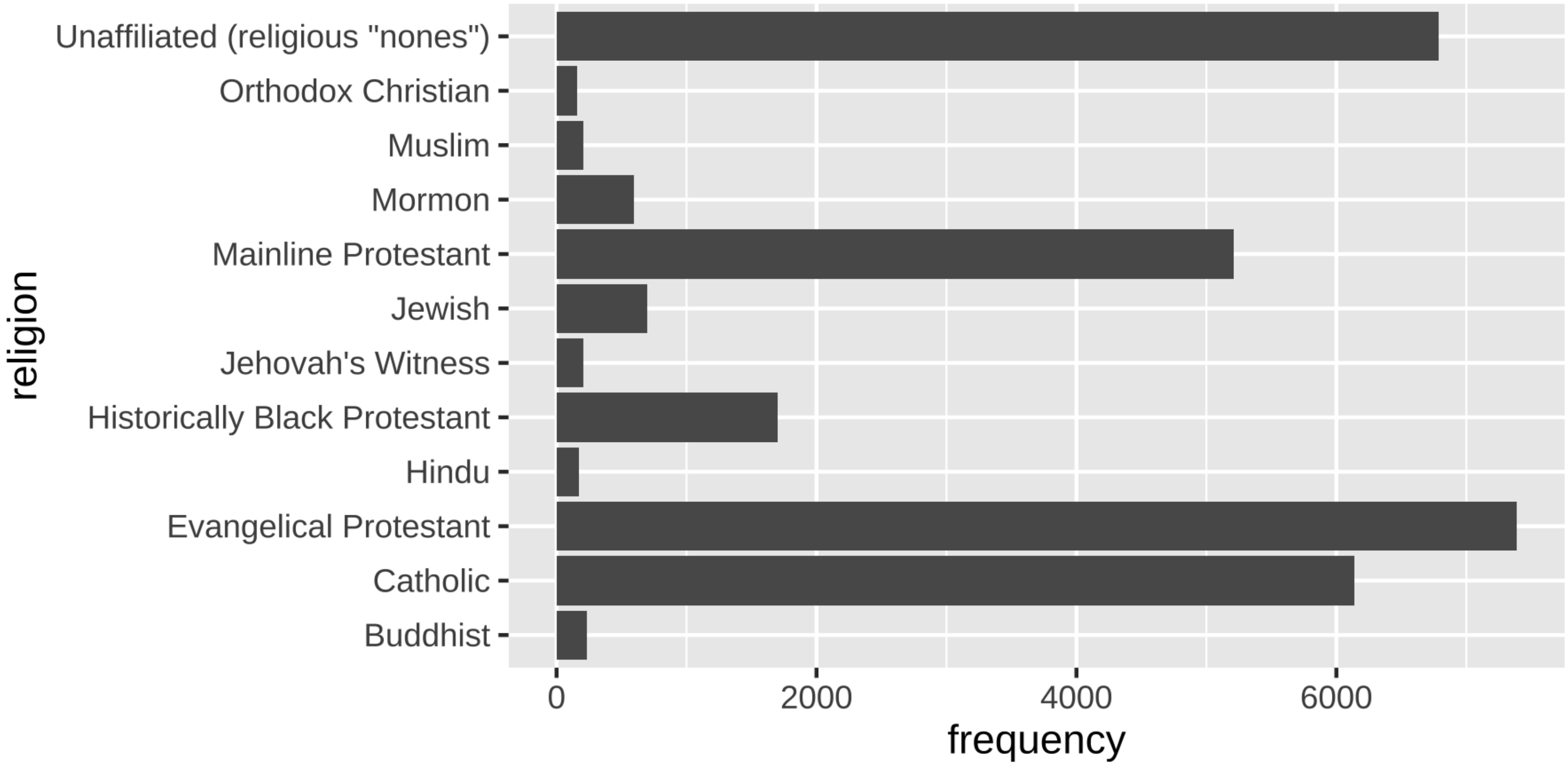
```
## # A tibble: 48 x 5
##   religion     n income             proportion frequency
##   <chr>    <dbl> <chr>                   <dbl>     <dbl>
## 1 Buddhist   233 Less than $30,000        0.36        84
## 2 Buddhist   233 $30,000-$49,999          0.18        42
## 3 Buddhist   233 $50,000-$99,999          0.32        75
## 4 Buddhist   233 $100,000 or more         0.13        30
## 5 Catholic  6137 Less than $30,000        0.36      2209
## 6 Catholic  6137 $30,000-$49,999          0.19      1166
## # … with 42 more rows
```

# Save data

```r
rel_inc_long <- rel_inc %>%
  rename(
    religion = `Religious tradition`,
    n = `Sample Size`
  ) %>%
  pivot_longer(
    cols = -c(religion, n),
    names_to = "income",
    values_to = "proportion"
  ) %>%
  mutate(frequency = round(proportion * n))
```

# Religion

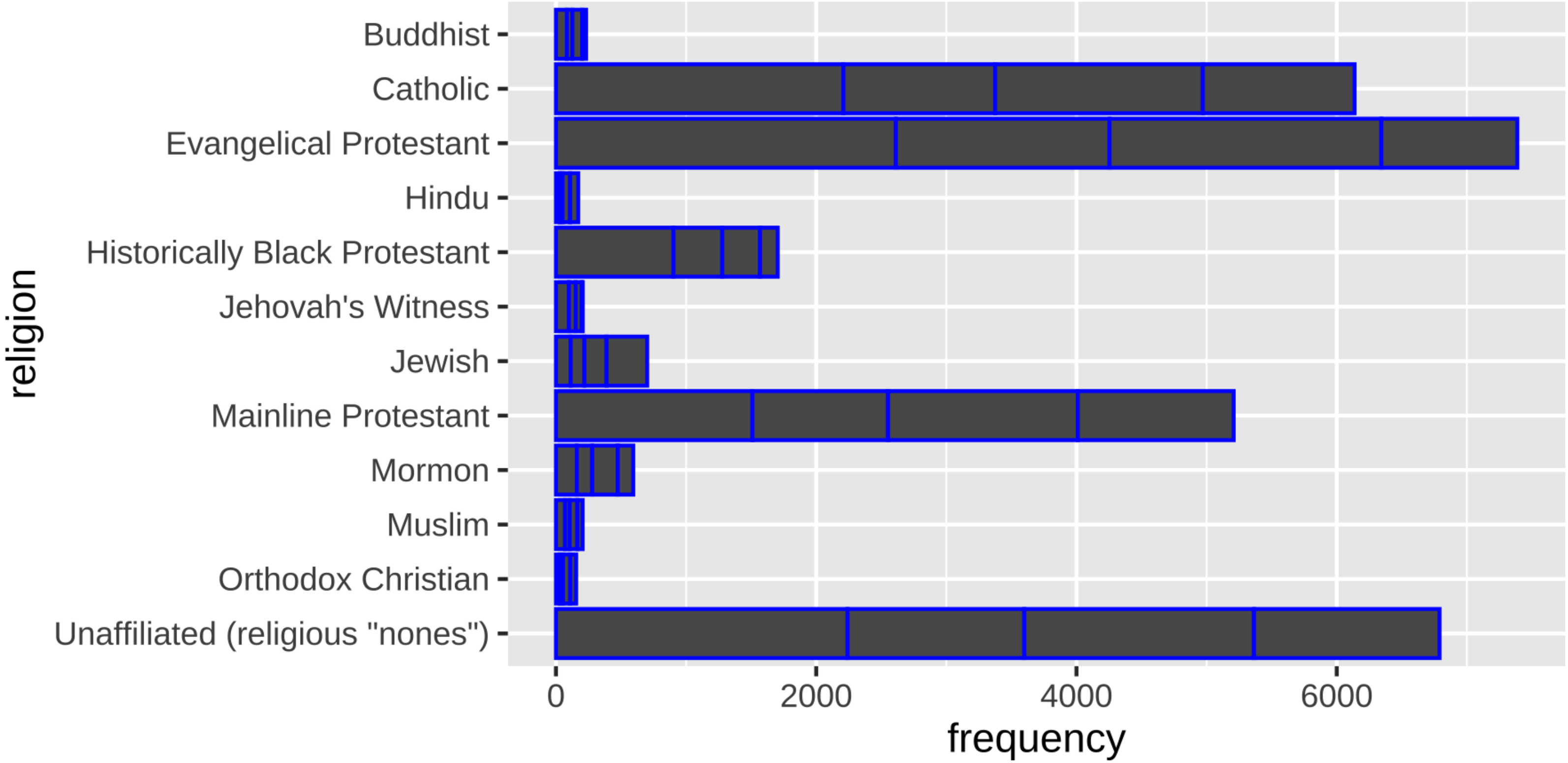
```
ggplot(rel_inc_long, aes(y = religion, x = frequency)) +
  geom_col()
```



# Reverse religion order

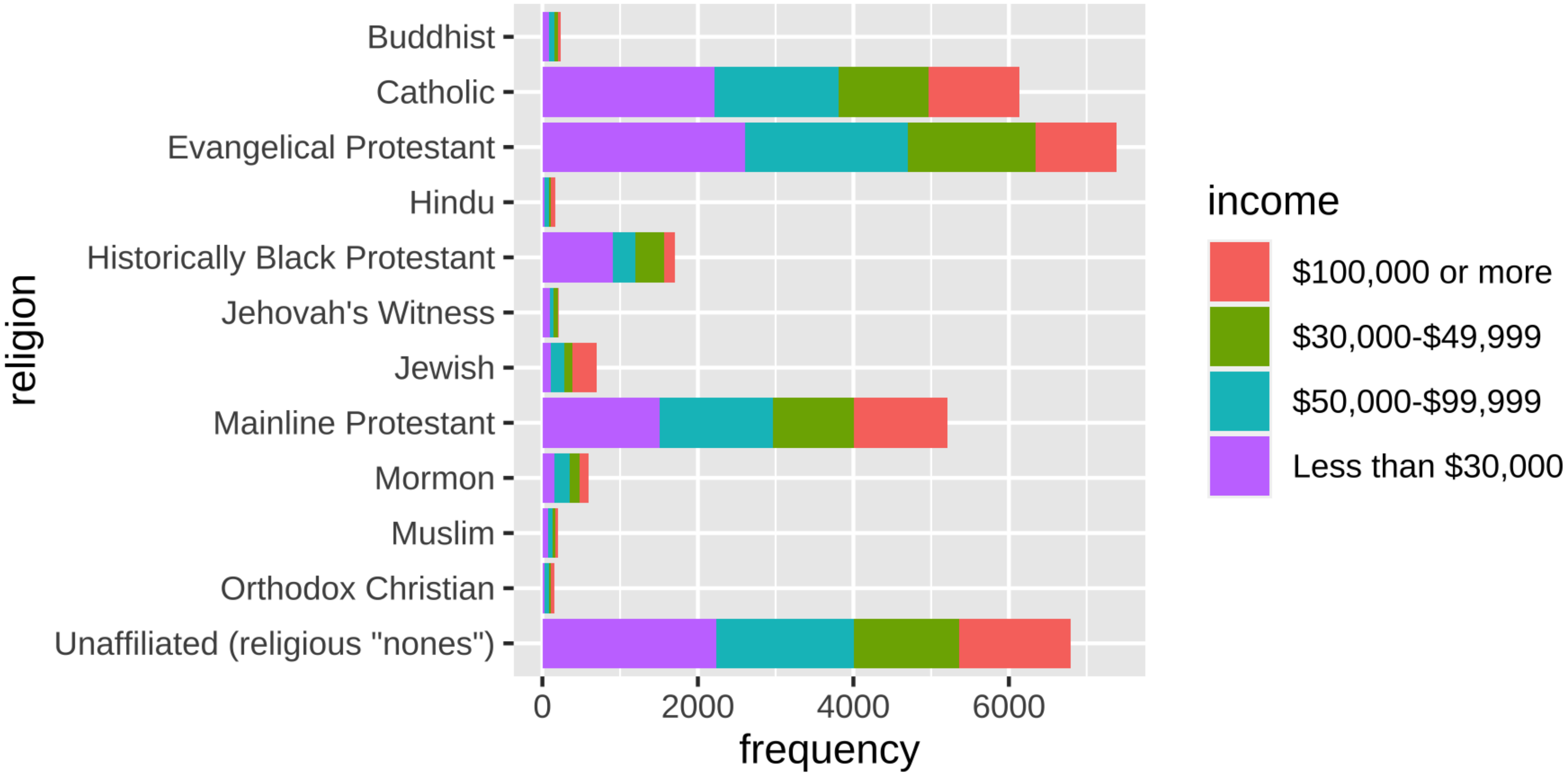
```r
rel_inc_long <- rel_inc_long %>%
  mutate(religion = fct_rev(religion))

ggplot(rel_inc_long, aes(y = religion, x = frequency)) +
  geom_col(color = "blue")
```



# Add income

```
ggplot(rel_inc_long, aes(y = religion, x = frequency, fill = income)) +
  geom_col()
```

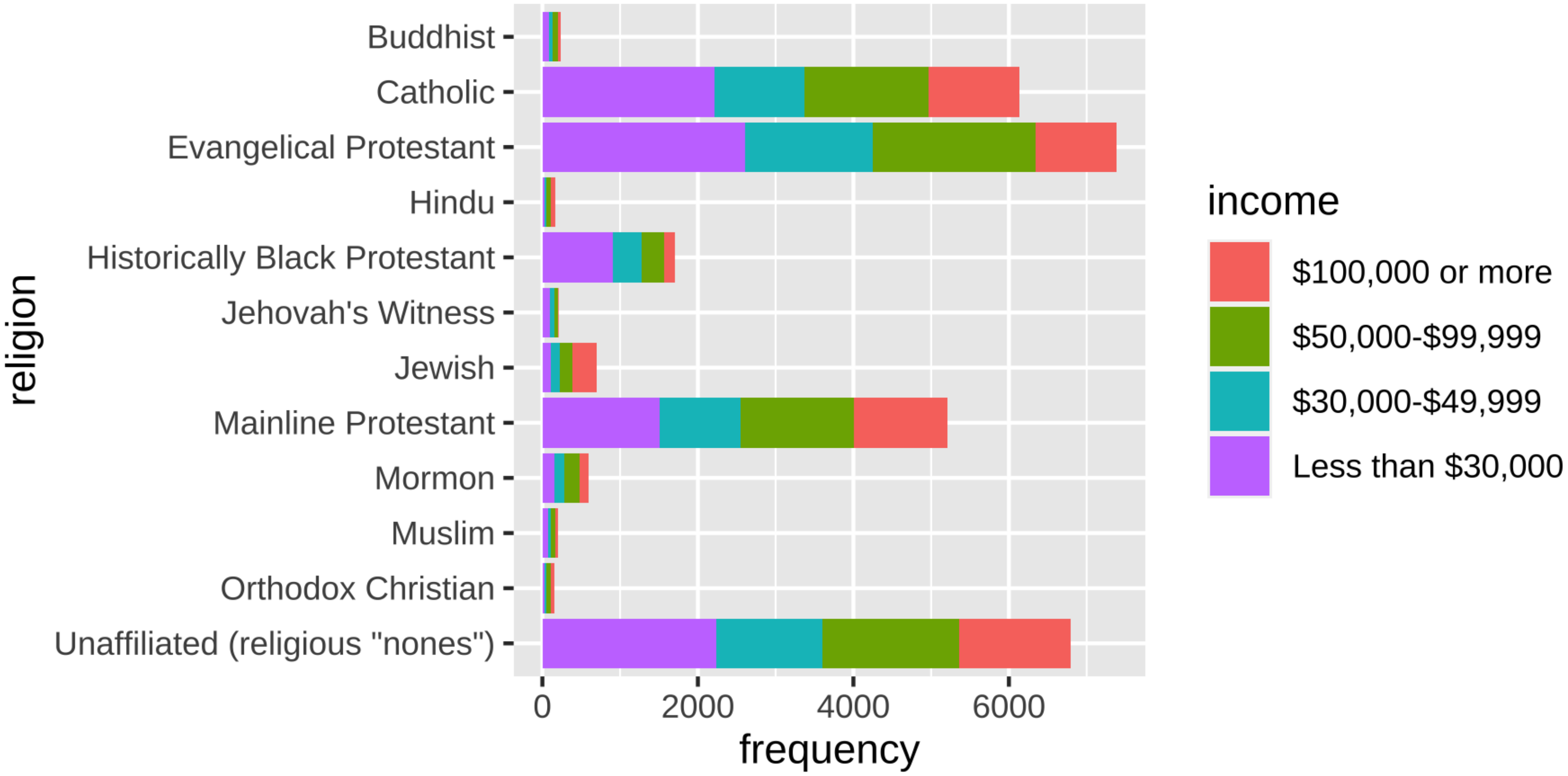


# Fix income level ordering

```r
rel_inc_long <- rel_inc_long %>%
  mutate(
    income = fct_relevel(income, "$100,000 or more",
                         "$50,000-$99,999", "$30,000-$49,999",
                         "Less than $30,000")
    )
```

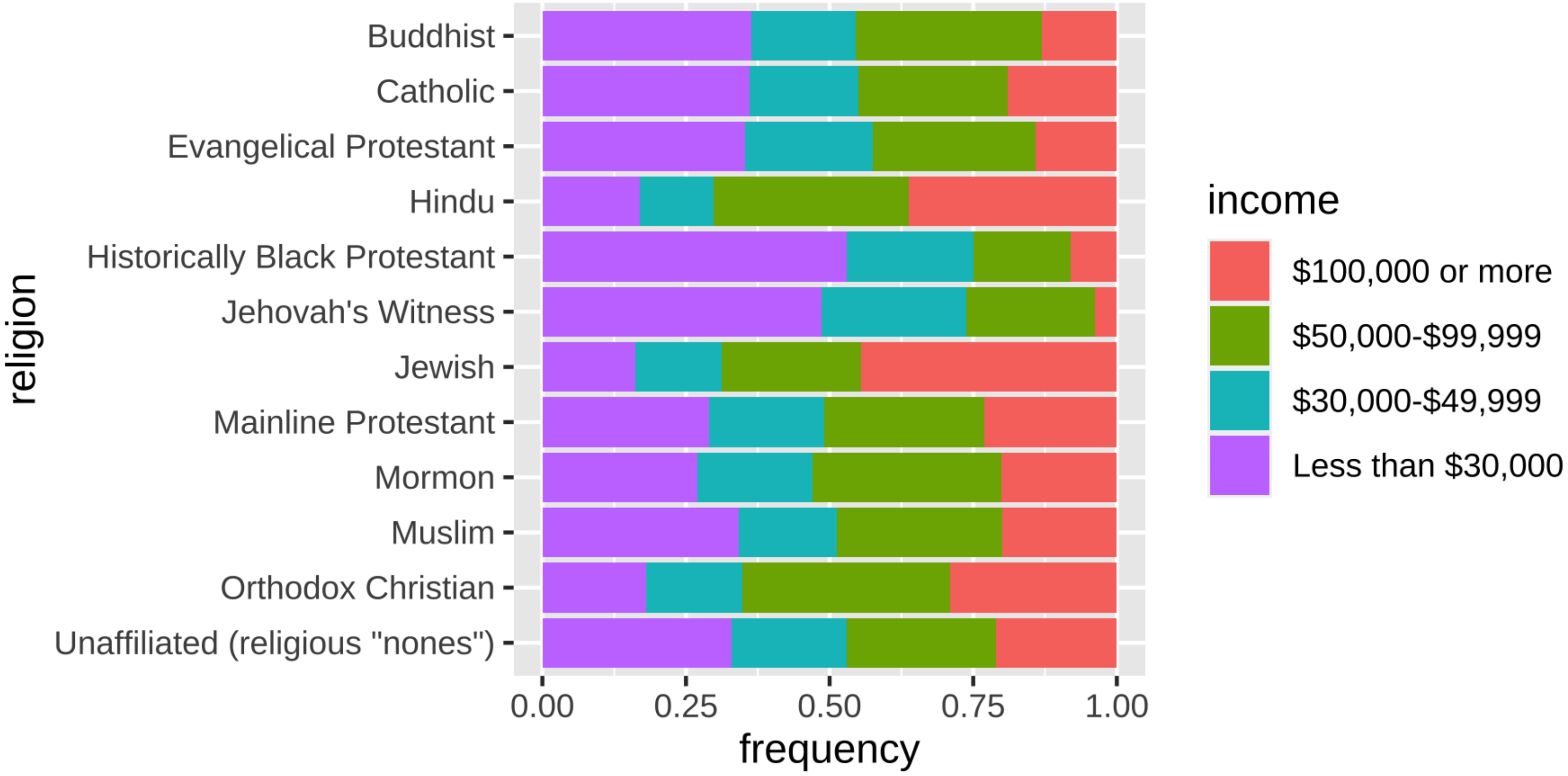
# Plot again

```
ggplot(rel_inc_long, aes(y = religion, x = frequency, fill = income)) +
  geom_col()
```



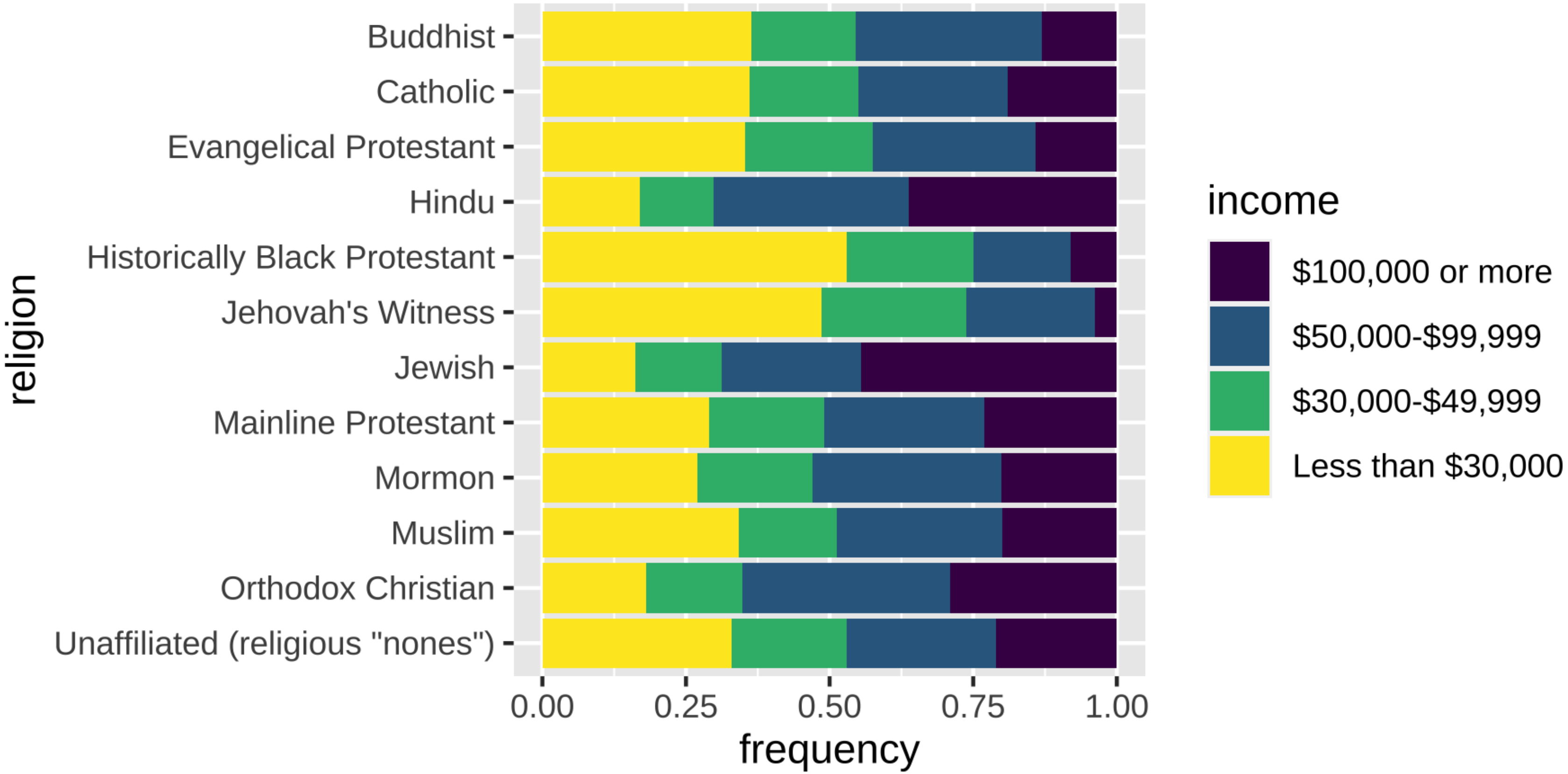
# Fill bars

```
ggplot(rel_inc_long, aes(y = religion, x = frequency, fill = income)) +
  geom_col(position = "fill")
```



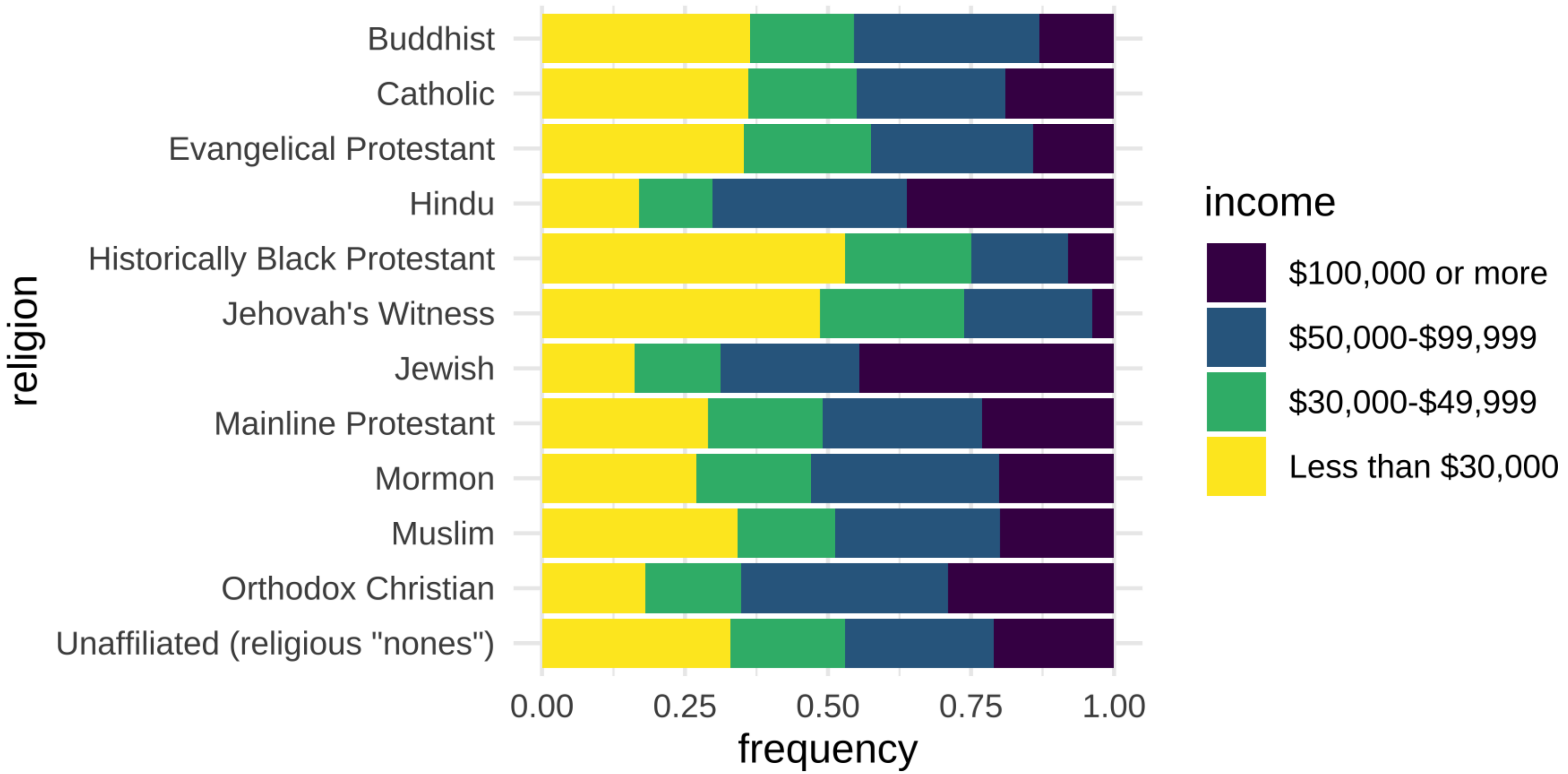
# Change colors

```
ggplot(rel_inc_long, aes(y = religion, x = frequency, fill = income)) +
  geom_col(position = "fill") +
  scale_fill_viridis_d()
```



# Change theme

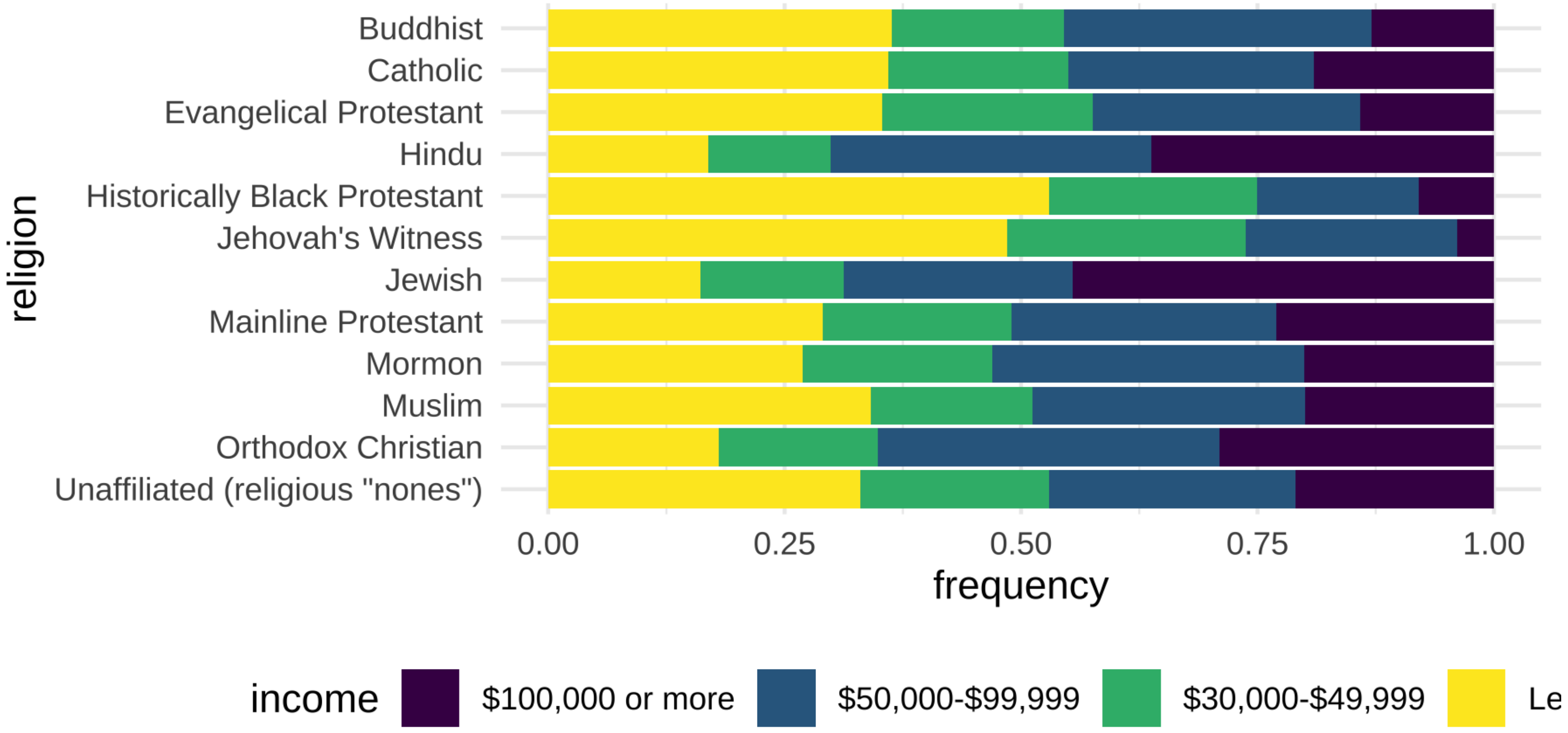
```
ggplot(rel_inc_long, aes(y = religion, x = frequency, fill = income)) +
  geom_col(position = "fill") +
  scale_fill_viridis_d() +
  theme_minimal()
```



# Move legend to the bottom

```
ggplot(rel_inc_long, aes(y = religion, x = frequency, fill = income)) +
  geom_col(position = "fill") +
  scale_fill_viridis_d() +
  theme_minimal() +
  theme(legend.position = "bottom")
```

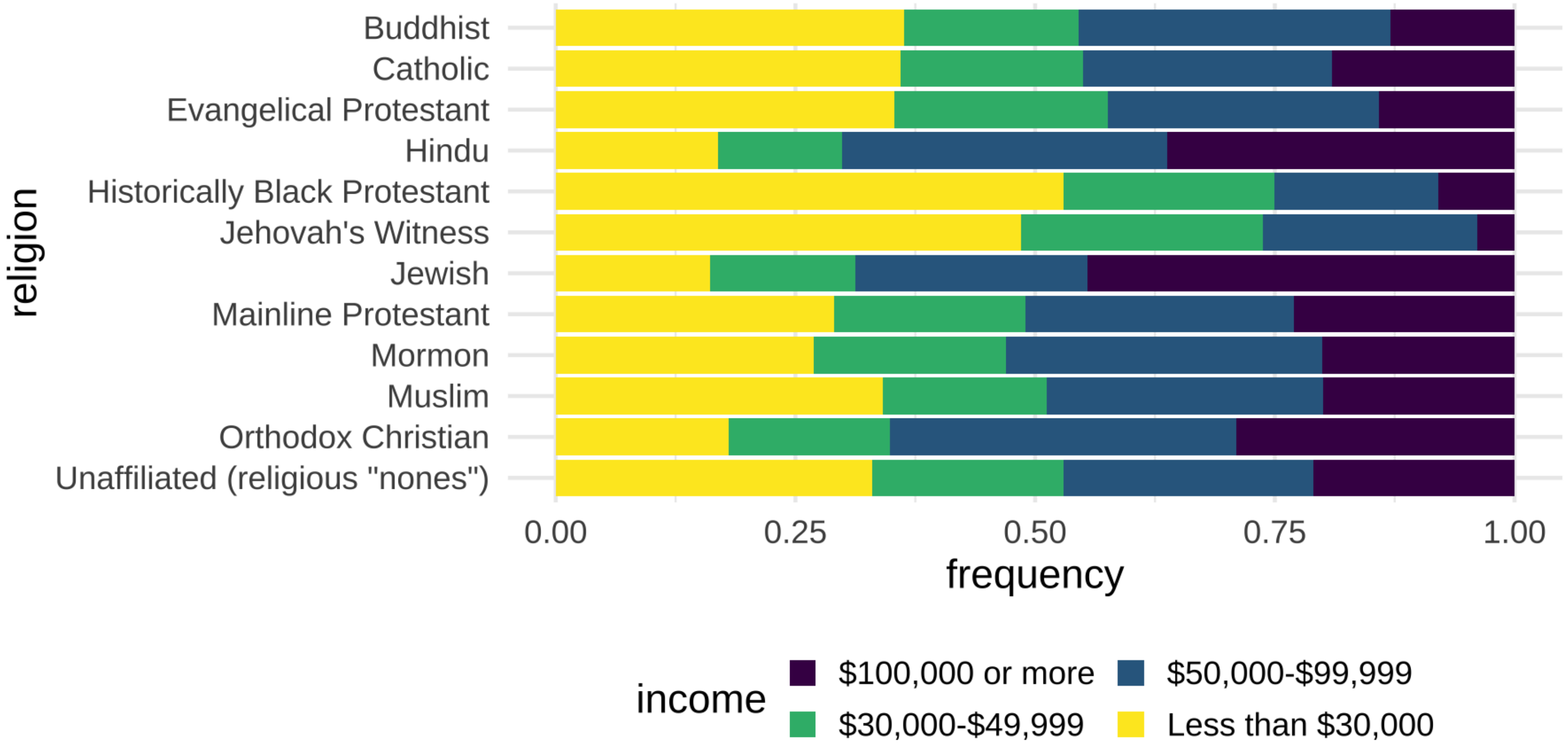
# Move legend to the bottom (plot)



# Legend adjustments

```
ggplot(rel_inc_long, aes(y = religion, x = frequency, fill = income)) +
  geom_col(position = "fill") +
  scale_fill_viridis_d() +
  theme_minimal() +
  theme(
    legend.position = "bottom",
    legend.key.size = unit(0.3, "cm"),
    legend.box.margin = margin(t = 0, r = 0, b = 0, l = 0, unit = "pt")
    ) +
  guides(fill = guide_legend(nrow = 2, byrow = TRUE))
```

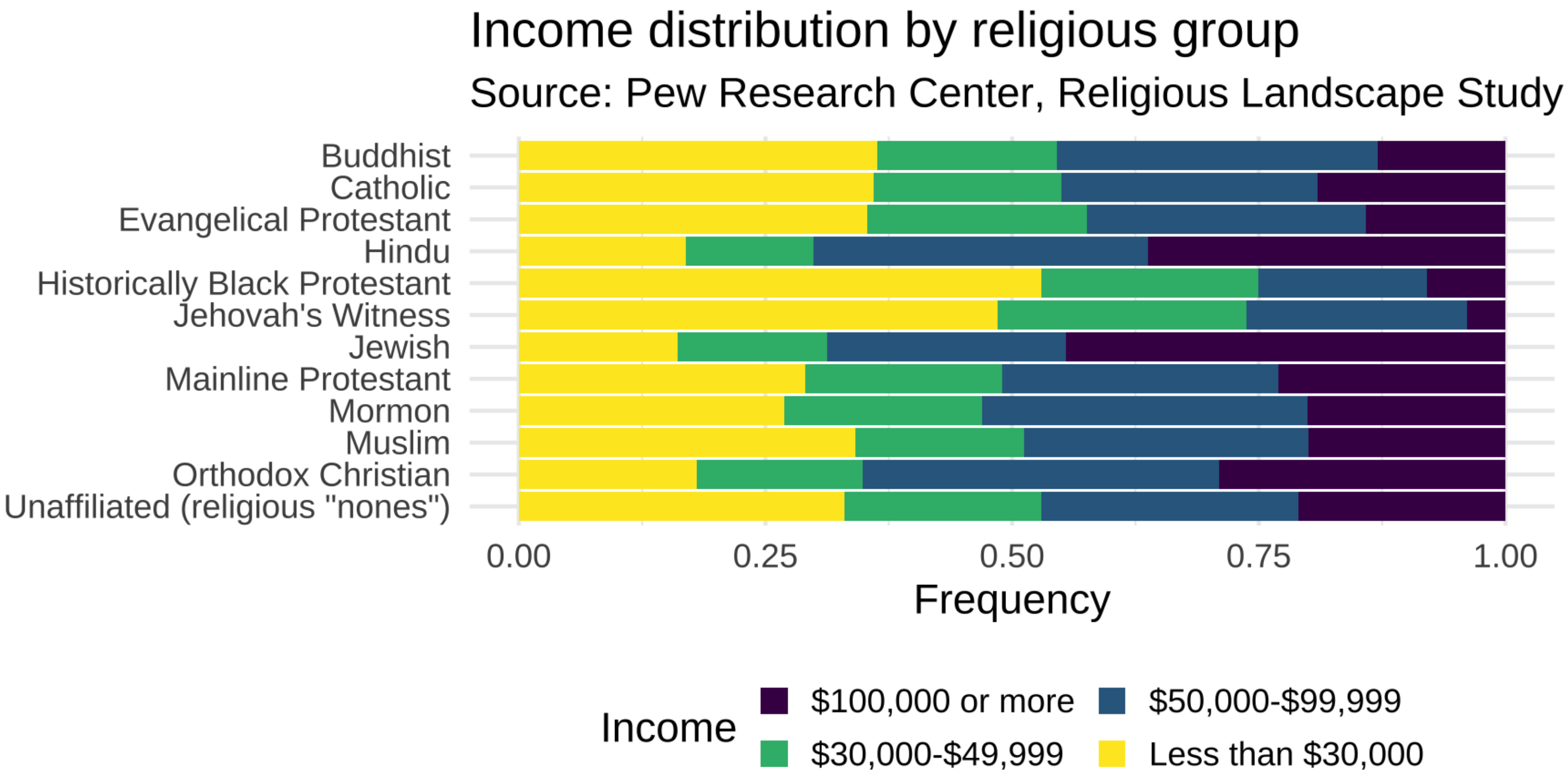
# Legend adjustments (plot)



# Fix labels

```r
ggplot(rel_inc_long, aes(y = religion, x = frequency, fill = income)) +
  geom_col(position = "fill") +
  scale_fill_viridis_d() +
  theme_minimal() +
  theme(
    legend.position = "bottom",
    legend.key.size = unit(0.3, "cm"),
    legend.box.margin = margin(t = 0, r = 0, b = 0, l = 0, unit = "pt")
    ) +
  guides(fill = guide_legend(nrow = 2, byrow = TRUE)) +
  labs(
    x = "Frequency", y = "",
    title = "Income distribution by religious group",
    subtitle = "Source: Pew Research Center, Religious Landscape Study",
    fill = "Income"
    )
```

# Fix labels (plot)


Income distribution by religious group
Source: Pew Research Center, Religious Landscape Study
Buddhist
Catholic
Evangelical Protestant
Hindu
Historically Black Protestant
Jehovah's Witness
Jewish
Mainline Protestant
Mormon
Muslim
Orthodox Christian
Unaffiliated (religious "nones")
Frequency
Income
$100,000 or more
$50,000-$99,999
$30,000-$49,999
Less than $30,000