Project 1: World Progress

In this project, you'll explore data from Gapminder.org, a website dedicated to providing a fact-based view of the world and how it has changed. That site includes several data visualizations and presentations, but also publishes the raw data that we will use in this project to recreate and extend some of their most famous visualizations.

The Gapminder website collects data from many sources and compiles them into tables that describe many countries around the world. All of the data they aggregate are published in the Systema Globalis. Their goal is "to compile all public statistics; Social, Economic and Environmental; into a comparable total dataset." All data sets in this project are copied directly from the Systema Globalis without any changes.

Logistics

Deadline. This project is due at 11:59pm on Monday, Feb 26.

Checkpoint. For full credit, you must also complete the first 8 questions and submit the preliminary assignment by 11:59pm on Thursday, Feb 22. After you've submitted the checkpoint, you may still change your answers before the project deadline - only your final submission will be graded for correctness.

Rules. Don't share your code with other students. You are welcome to discuss questions with other students, but don't share the answers. If someone asks you for the answer, resist! Instead, you can demonstrate how you would solve a similar problem.

Advice. Develop your answers incrementally. To perform a complicated table manipulation, break it up into steps, perform each step on a different line, give a new name to each result, and check that each intermediate result is what you expect. You can add any additional names or functions you want to the provided cells. Make sure that you are using distinct and meaningful variable names throughout the notebook. Along that line, **DO NOT** reuse the variable names that we use when we grade your answers. For example, in Question 1 of the Global Poverty section, we ask you to assign an answer to `latest`. Do not reassign the variable name `latest` to anything else in your notebook, otherwise there is the chance that our tests grade against what `latest` was reassigned to.

You **never** have to use just one line in this project or any others. Use intermediate variables and multiple lines as much as you would like!

To get started, load `datascience`, `numpy`, `plots`, and `ok` by running the cell below.

```
from datascience import *
import numpy as np

%matplotlib inline
import matplotlib.pyplot as plots
plots.style.use('fivethirtyeight')
```

1. Global Population Growth

The global population of humans reached 1 billion around 1800, 3 billion around 1960, and 7 billion around 2011. The potential impact of exponential population growth has concerned scientists, economists, and politicians alike.

The UN Population Division estimates that the world population will likely continue to grow throughout the 21st century, but at a slower rate, perhaps reaching 11 billion by 2100. However, the UN does not rule out scenarios of more extreme growth.

In this section, we will examine some of the factors that influence population growth and how they are changing around the world.

The first table we will consider is the total population of each country over time. Run the cell below.

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mour
```

```
population = Table.read_table('/content/drive/MyDrive/population.csv')
population.show(3)
```

geo	time	population_total
abw	1800	19286
abw	1801	19286
abw	1802	19286

... (87792 rows omitted)

Note: The data for this project was downloaded in February 2017.

Bangladesh

In the `population` table, the `geo` column contains three-letter codes established by the International Organization for Standardization (ISO) in the Alpha-3 standard. We will begin by taking a close look at Bangladesh. Inspect the standard to find the 3-letter code for Bangladesh.

Question 1. Create a table called `b_pop` that has two columns labeled `time` and `population_total`. The first column should contain the years from 1970 through 2015 (including both 1970 and 2015) and the second should contain the population of Bangladesh in each of those years.

```
b_pop = population.where("geo", are.equal_to("bgd")).select("time", "population_total")
b_pop
```

time	population_total
1600	12918659
1601	12944609
1602	12970611
1603	12996665
1604	13022772
1605	13048931
1606	13075143
1607	13101407
1608	13127724
1609	13154094

... (491 rows omitted)

Run the following cell to create a table called `b_five` that has the population of Bangladesh every five years. At a glance, it appears that the population of Bangladesh has been growing quickly indeed!

```
b_pop.set_format('population_total', NumberFormatter)

fives = np.arange(1970, 2016, 5) # 1970, 1975, 1980, ...
b_five = b_pop.sort('time').where('time', are.contained_in(fives))
b_five
```

time	population_total
1970	65,048,701
1975	71,247,153
1980	81,364,176
1985	93,015,182
1990	105,983,136
1995	118,427,768
2000	131,280,739
2005	142,929,979
2010	151,616,777
2015	160,995,642

Question 2. Assign `initial` to an array that contains the population for every five year interval from 1970 to 2010. Then, assign `changed` to an array that contains the population for every five year interval from 1975 to 2015. You should use the `b_five` table to create both arrays, first filtering the table to only contain the relevant years.

We have provided the code below that uses `initial` and `changed` in order to add a column to `b_five` called `annual_growth`. Don't worry about the calculation of the growth rates; run the test below to test your solution.

In case you're curious where the formula in the second to last line comes from, The general formula for growth rate is (final/beginning)^(1/t)-1, where t is time in years.

```
initial = b_five.sort('time').where('time', are.between(1970,2010))
changed = b_five.sort('time').where('time', are.between(1975,2015))
initial

#b_1970_through_2010 = b_five.where('time', are.below_or_equal_to(2010))
#b_five_growth = b_1970_through_2010.with_column('annual_growth', (changed/initial)**0.2-1)
#b_five_growth.set_format('annual_growth', PercentFormatter)
```

time	population_total
1970	65,048,701
1975	71,247,153
1980	81,364,176
1985	93,015,182
1990	105,983,136
1995	118,427,768
2000	131,280,739
2005	142,929,979

While the population has grown every five years since 1970, the annual growth rate decreased dramatically from 1985 to 2005. Let's look at some other information in order to develop a possible explanation. Run the next cell to load three additional tables of measurements about countries over time.

```
life_expectancy = Table.read_table('/content/drive/MyDrive/life_expectancy.csv')
child_mortality = Table.read_table('/content/drive/MyDrive/child_mortality.csv').relabel(2,
fertility = Table.read_table('/content/drive/MyDrive/fertility.csv')
```

The `life_expectancy` table contains a statistic that is often used to measure how long people live, called *life expectancy at birth*. This number, for a country in a given year, does not measure how long babies born in that year are expected to live. Instead, it measures how long someone would live, on average, if the *mortality conditions* in that year persisted throughout their lifetime. These "mortality conditions" describe what fraction of people at each age survived the year. So, it is a way of measuring the proportion of people that are staying alive, aggregated over different age groups in the population.

Run the following cells below to see `life_expectancy`, `child_mortality`, and `fertility`. Refer back to these tables as they will be helpful for answering further questions!

```
life_expectancy
```

geo	time	life_expectancy_years
afg	1800	28.21
afg	1801	28.2
afg	1802	28.19
afg	1803	28.18
afg	1804	28.17
afg	1805	28.16
afg	1806	28.15
afg	1807	28.14
afg	1808	28.13
afg	1809	28.12

... (43847 rows omitted)

`child_mortality`

geo	time	child_mortality_under_5_per_1000_born
afg	1800	468.6
afg	1801	468.6
afg	1802	468.6
afg	1803	468.6
afg	1804	468.6
afg	1805	468.6
afg	1806	470
afg	1807	470
afg	1808	470
afg	1809	470

... (40746 rows omitted)

`fertility`

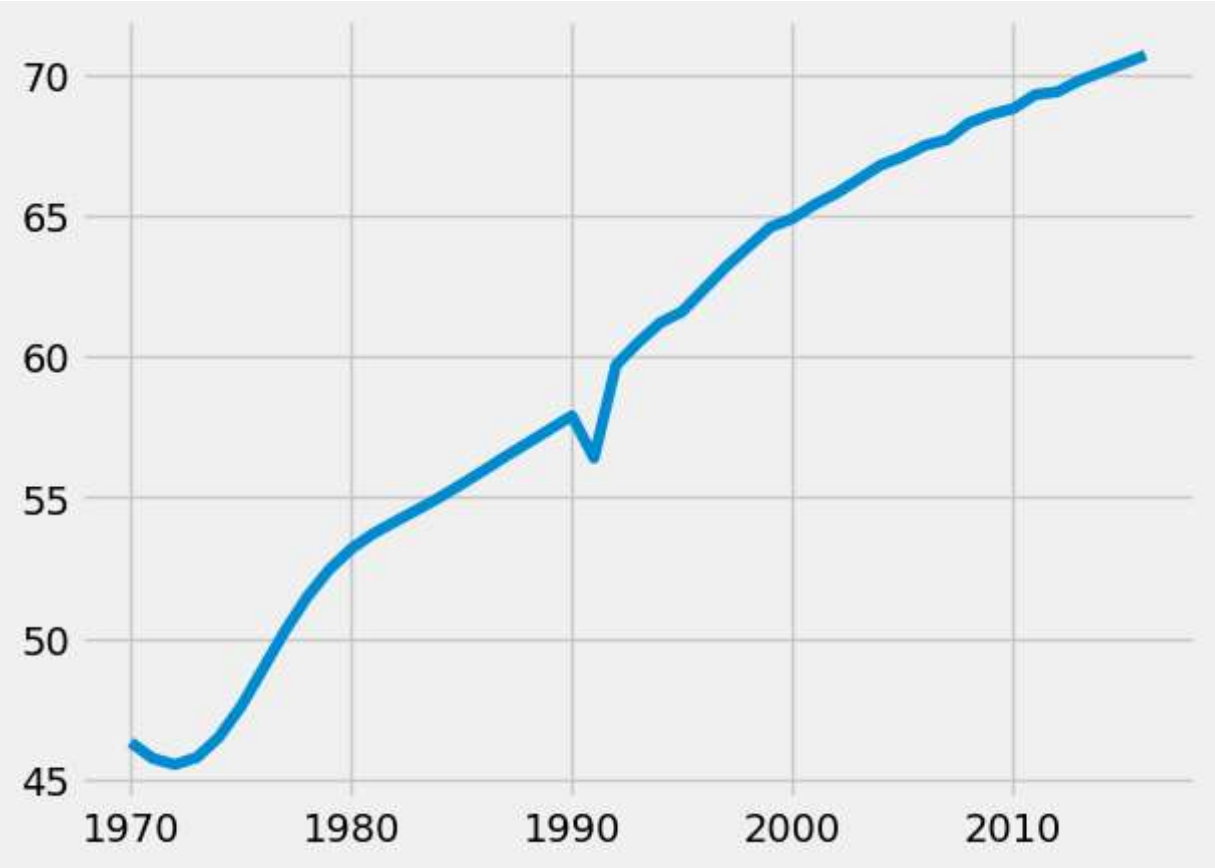
geo	time	children_per_woman_total_fertility
afg	1800	7
afg	1801	7
afg	1802	7
afg	1803	7
afg	1804	7
afg	1805	7
afg	1806	7
afg	1807	7
afg	1808	7
afg	1809	7

... (43402 rows omitted)

Question 3. Perhaps population is growing more slowly because people aren't living as long. Use the `life_expectancy` table to draw a line graph with the years 1970 and later on the horizontal axis that shows how the *life expectancy at birth* has changed in Bangladesh.

```
#Fill in code here
life_expectancy_1970 = life_expectancy.where("geo", are.equal_to("bgd")).sort('time').where(
plots.plot(life_expectancy_1970.column(1),life_expectancy_1970.column(2))
```

```
[<matplotlib.lines.Line2D at 0x7926c6bfc7c0>]
```



Question 4. Assuming everything else stays the same, do the trends in life expectancy in the graph above directly explain why the population growth rate decreased from 1985 to 2010 in Bangladesh? Why or why not?

Hint: What happened in Bangladesh in 1991, and does that event explain the overall change in population growth rate?

The graph itself doesn't directly explain what happened but you can figure out a lot of people must have died- after a quick google search it must be the cyclone that hit bangladesh in 1991- very unfortunate

The `fertility` table contains a statistic that is often used to measure how many babies are being born, the *total fertility rate*. This number describes the number of children a woman would have in her lifetime, on average, if the current rates of birth by age of the mother persisted throughout her child bearing years, assuming she survived through age 49.

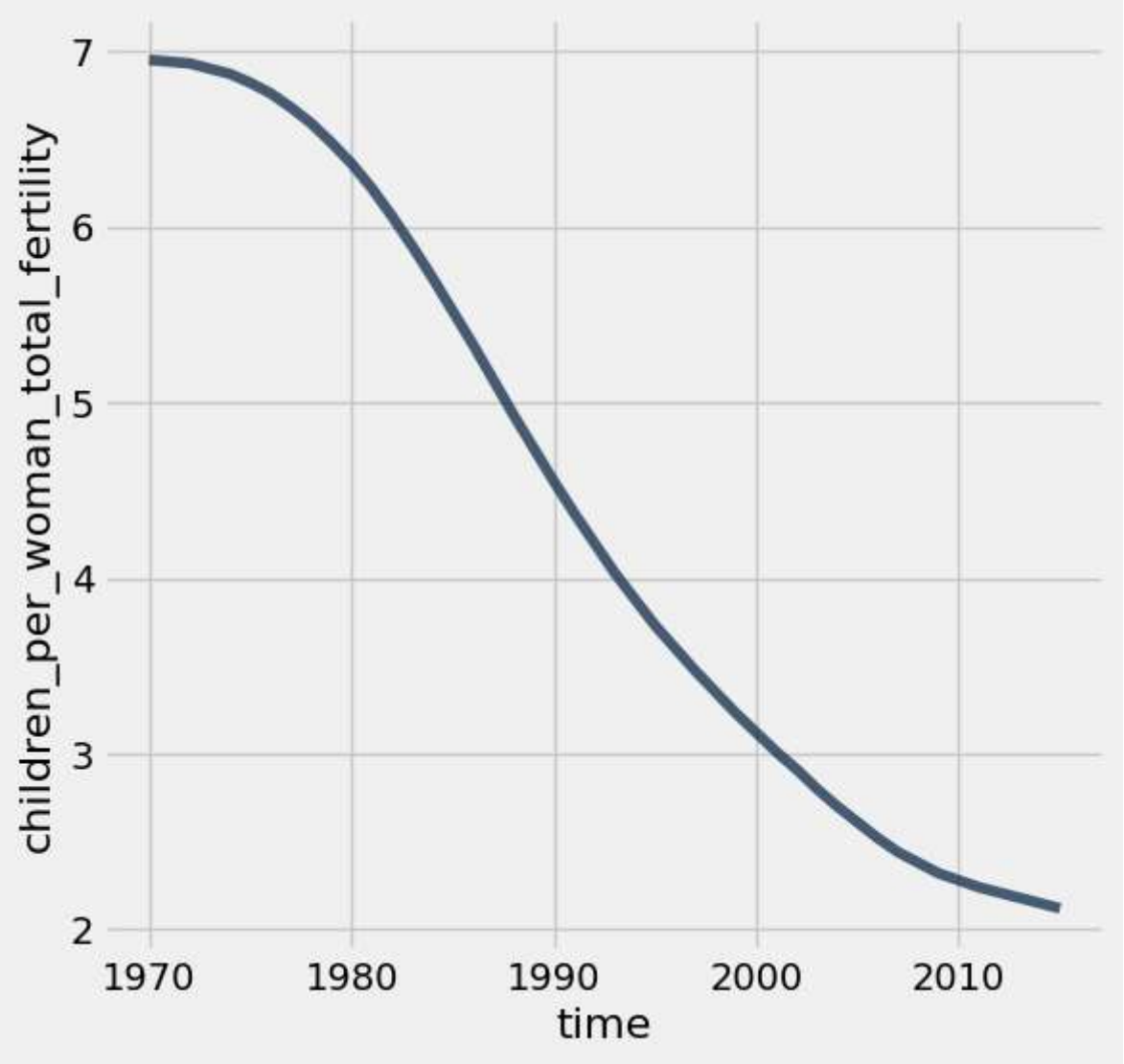
Question 5. Write a function `fertility_over_time` that takes the Alpha-3 code of a `country` and a `start` year. It returns a two-column table with labels `Year` and `Children per woman` that can be

used to generate a line chart of the country's fertility rate each year, starting at the `start` year. The plot should include the `start` year and all later years that appear in the `fertility` table.

Then, in the next cell, call your `fertility_over_time` function on the Alpha-3 code for Bangladesh and the year 1970 in order to plot how Bangladesh's fertility rate has changed since 1970. Note that the function `fertility_over_time` should not return the plot itself. **The expression that draws the line plot is provided for you; please don't change it.**

```
def fertility_over_time(country, start):
    """Create a two-column table that describes a country's total fertility rate each year."
    return fertility.where("geo", are.equal_to(country)).sort('time').where('time', are.abov
```

```
bangladesh_code = "bgd"
fertility_over_time(bangladesh_code, 1970).plot(0, 1) # You should *not* change this line.
```



Question 6. Assuming everything else is constant, do the trends in fertility in the graph above help directly explain why the population growth rate decreased from 1985 to 2010 in Bangladesh? Why

or why not?

Yes, the fertility directly affects population growth

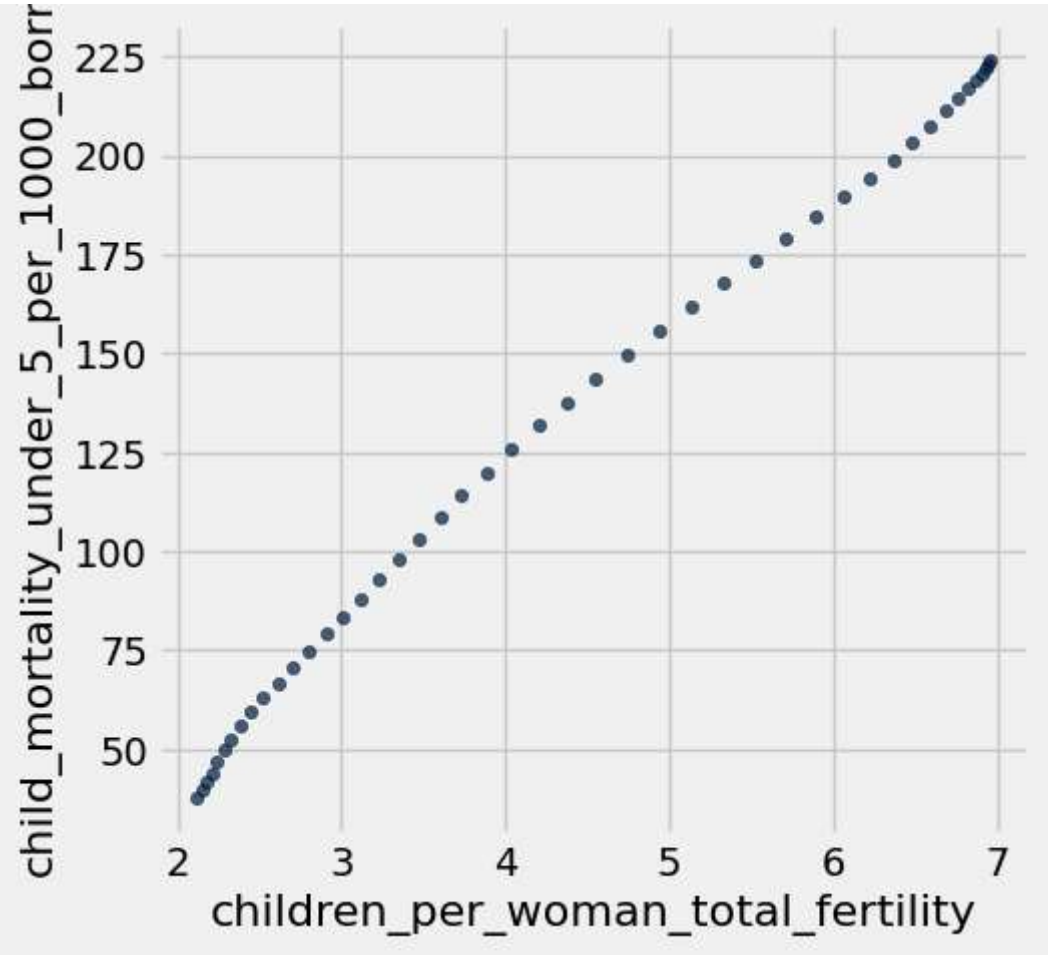
It has been observed that lower fertility rates are often associated with lower child mortality rates. The link has been attributed to family planning: if parents can expect that their children will all survive into adulthood, then they will choose to have fewer children. We can see if this association is evident in Bangladesh by plotting the relationship between total fertility rate and child mortality rate per 1000 children.

Question 7. Using both the `fertility` and `child_mortality` tables, draw a scatter diagram that has Bangladesh's total fertility on the horizontal axis and its child mortality on the vertical axis with one point for each year, starting with 1970.

The expression that draws the scatter diagram is provided for you; please don't change it. Instead, create a table called `post_1969_fertility_and_child_mortality` with the appropriate column labels and data in order to generate the chart correctly. Use the label `Children per woman` to describe total fertility and the label `Child deaths per 1000 born` to describe child mortality.

```
bgd_fertility = fertility.where("geo", are.equal_to("bgd")).sort('time').where('time', are.a
bgd_child_mortality = child_mortality.where("geo", are.equal_to("bgd")).sort('time').where('
fertility_and_child_mortality = bgd_fertility.join("time",bgd_child_mortality)
post_1969_fertility_and_child_mortality = fertility_and_child_mortality

post_1969_fertility_and_child_mortality.scatter('children_per_woman_total_fertility', 'childc
```



Question 8. In one or two sentences, describe the association (if any) that is illustrated by this scatter diagram. Does the diagram show that reduced child mortality causes parents to choose to have fewer children?

yes- thats absolutely what this shows- and as the mortality rate increases more children are had to even it out.

Checkpoint (due Friday 2/24)

Congratulations, you have reached the checkpoint! Please submit a pdf of this preliminary assignment to Canvas by February 24 at 11:59pm.

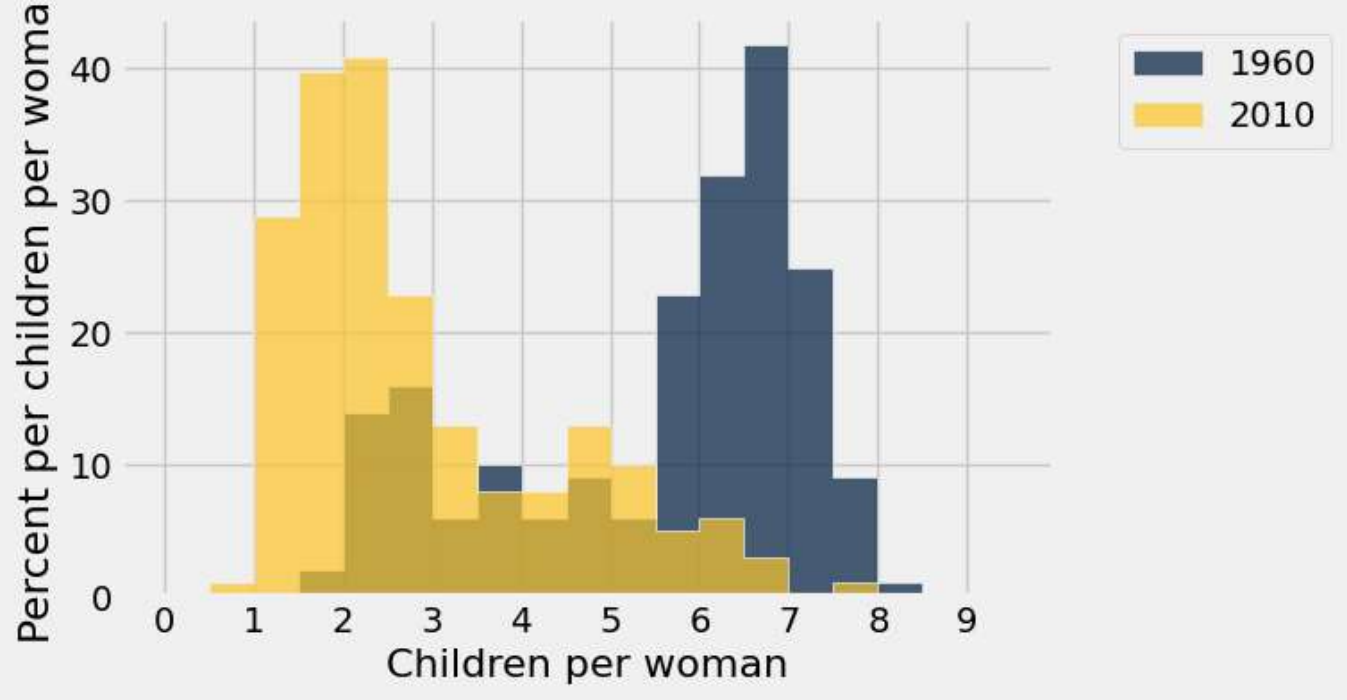
To do this, print your notebook as a pdf. Go to File -> Print -> save as pdf. Then upload the pdf to the corresponding project assignment on Canvas.

The World

The change observed in Bangladesh since 1970 can also be observed in many other developing countries: health services improve, life expectancy increases, and child mortality decreases. At the same time, the fertility rate often plummets, and so the population growth rate decreases despite increasing longevity.

Run the cell below to generate two overlaid histograms, one for 1960 and one for 2010, that show the distributions of total fertility rates for these two years among all 201 countries in the `fertility` table.

```
Table().with_columns(
    '1960', fertility.where('time', 1960).column(2),
    '2010', fertility.where('time', 2010).column(2)
).hist(bins=np.arange(0, 10, 0.5), unit='child per woman')
_ = plots.xlabel('Children per woman')
_ = plots.ylabel('Percent per children per woman')
_ = plots.xticks(np.arange(10))
```



Question 9. Assign `fertility_statements` to an array of the numbers of each statement below that can be correctly inferred from these histograms.

1. About the same number of countries had a fertility rate between 3.5 and 4.5 in both 1960 and 2010.
2. In 2010, about 40% of countries had a fertility rate between 1.5 and 2.
3. In 1960, less than 20% of countries had a fertility rate below 3.

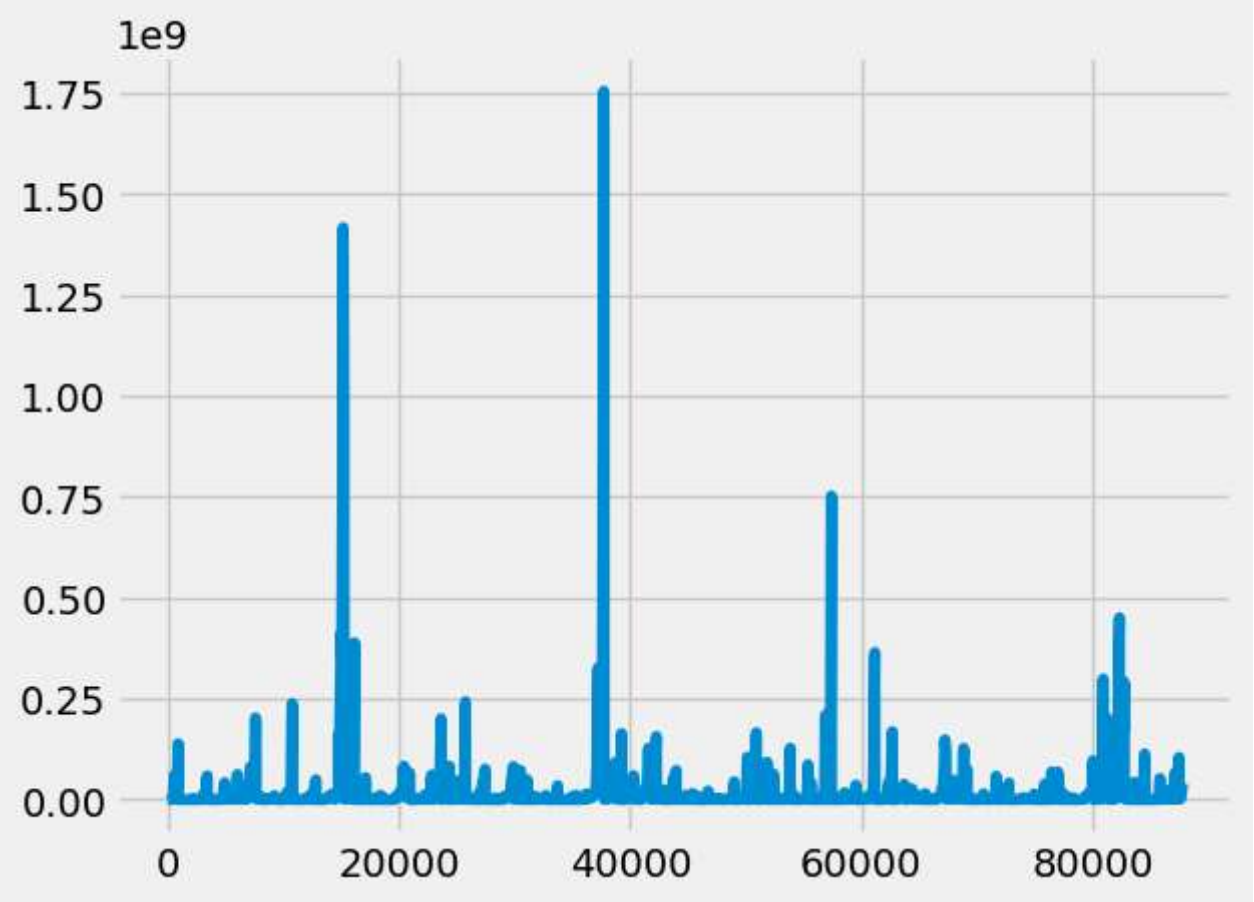
4. More countries had a fertility rate above 3 in 1960 than in 2010.
5. At least half of countries had a fertility rate between 5 and 8 in 1960.
6. At least half of countries had a fertility rate below 3 in 2010.

```
fertility_statements = [2,3,4,5,6]
```

Question 10. Draw a line plot of the world population from 1800 through 2005. The world population is the sum of all the country's populations.

```
#Fill in code here
plots.plot(population.column(2))
```

```
[<matplotlib.lines.Line2D at 0x7926c2ab69b0>]
```



Question 11. Create a function `stats_for_year` that takes a `year` and returns a table of statistics. The table it returns should have four columns: `geo`, `population_total`, `children_per_woman_total_fertility`, and `child_mortality_under_5_per_1000_born`. Each row should contain one Alpha-3 country code and three statistics: population, fertility rate, and child mortality for that `year` from the `population`, `fertility` and `child_mortality` tables. Only include rows for which all three statistics are available for the country and year.

In addition, restrict the result to country codes that appears in `big_50`, an array of the 50 most populous countries in 2010. This restriction will speed up computations later in the project.

After you write `stats_for_year`, try calling `stats_for_year` on any year between 1960 and 2010. Try to understand the output of stats_for_year.

```
# We first create a population table that only includes the
# 50 countries with the largest 2010 populations. We focus on
# these 50 countries only so that plotting later will run faster.
big_50 = population.where('time', are.equal_to(2010)).sort("population_total", descending=Tr
population_of_big_50 = population.where('time', are.above(1959)).where('geo', are.contained_

def stats_for_year(year):
    """Return a table of the stats for each country that year."""
    p = population_of_big_50.where('time', are.equal_to(year)).drop('time')
    f = fertility.where('time', are.equal_to(year)).drop('time')
    c = child_mortality.where('time', are.equal_to(year)).drop('time')
    return p.join("geo",f, "geo").join("geo",c, "geo")

stats_for_year(2010)
```

geo	population_total	children_per_woman_total_fertility	child_mortality_under_5_per_
afg	27962207	5.66	
arg	41222875	2.22	
bgd	151616777	2.28	
bra	198614208	1.84	
can	34126173	1.63	
chn	1340968737	1.54	
cod	65938712	6.25	
col	45918101	2.38	
deu	80435307	1.39	
dza	36036159	2.82	

... (40 rows omitted)

Question 12. Create a table called `pop_by_decade` with two columns called `decade` and `population`. It has a row for each `year` since 1960 that starts a decade. The `population` column contains the total population of all countries included in the result of `stats_for_year(year)` for the first `year` of the decade. For example, 1960 is the first year of the 1960's decade. You should see that these countries contain most of the world's population.

Hint: One approach is to define a function `pop_for_year` that computes this total population, then `apply` it to the `decade` column. The `stats_for_year` function from the previous question may be useful here.

This first test is just a sanity check for your helper function if you choose to use it. You will not lose points for not implementing the function `pop_for_year`.

Note: The cell where you will generate the `pop_by_decade` table is below the cell where you can choose to define the helper function `pop_for_year`. You should define your `pop_by_decade` table in the cell that starts with the table `decades` being defined.

```
def pop_for_year(year):
  #start = population.select("time", "population_total").where("time", are.equal_to(year)).g

  return sum(stats_for_year(year).column("population_total"))
print(pop_for_year(1960))

def pop_for_decade(decade):
  total = 0;
  for x in range(10):
    total += pop_for_year(decade+x)

  return total;

print(pop_for_decade(1960))
```

```
2624944597
28717048854
28717048854
```

Now that you've defined your helper function (if you've chosen to do so), define the `pop_by_decade` table.

```
decades = Table().with_column('decade', np.arange(1960, 2010, 10));
```

```
pop_by_decade = decades.with_column("population", decades.apply(pop_for_decade, "decade"))
pop_by_decade
#pop_by_decade.set_format(1, NumberFormatter)
```

```
28717048854
35131537000
42138676537
49846418253
56693108974
```

decade	population
1960	28717048854
1970	35131537000
1980	42138676537
1990	49846418253
2000	56693108974

The `countries` table describes various characteristics of countries. The `country` column contains the same codes as the `geo` column in each of the other data tables (`population`, `fertility`, and `child_mortality`). The `world_6region` column classifies each country into a region of the world. Run the cell below to inspect the data.

```
countries = Table.read_table('/content/drive/MyDrive/countries.csv').where('country', are.cc
countries.select('country', 'name', 'world_6region')
```

country	name	world_6region
afg	Afghanistan	south_asia
akr_a_dhe	Akrotiri and Dhekelia	europe_central_asia
alb	Albania	europe_central_asia
dza	Algeria	middle_east_north_africa
asm	American Samoa	east_asia_pacific
and	Andorra	europe_central_asia
ago	Angola	sub_saharan_africa
aia	Anguilla	america
atg	Antigua and Barbuda	america
arg	Argentina	america

... (245 rows omitted)

Question 13. Create a table called `region_counts` that has two columns, `region` and `count`. It should contain two columns: a region column and a count column that contains the number of

countries in each region that appear in the result of `stats_for_year(1960)`. For example, one row would have `south_asia` as its `world_6region` value and an integer as its `count` value: the number of large South Asian countries for which we have population, fertility, and child mortality numbers from 1960.

```
region_counts = stats_for_year(1960).join('geo',countries, 'country').group('world_6region')
region_counts
```

world_6region	count
america	8
east_asia_pacific	10
europe_central_asia	10
middle_east_north_africa	7
south_asia	5
sub_saharan_africa	10

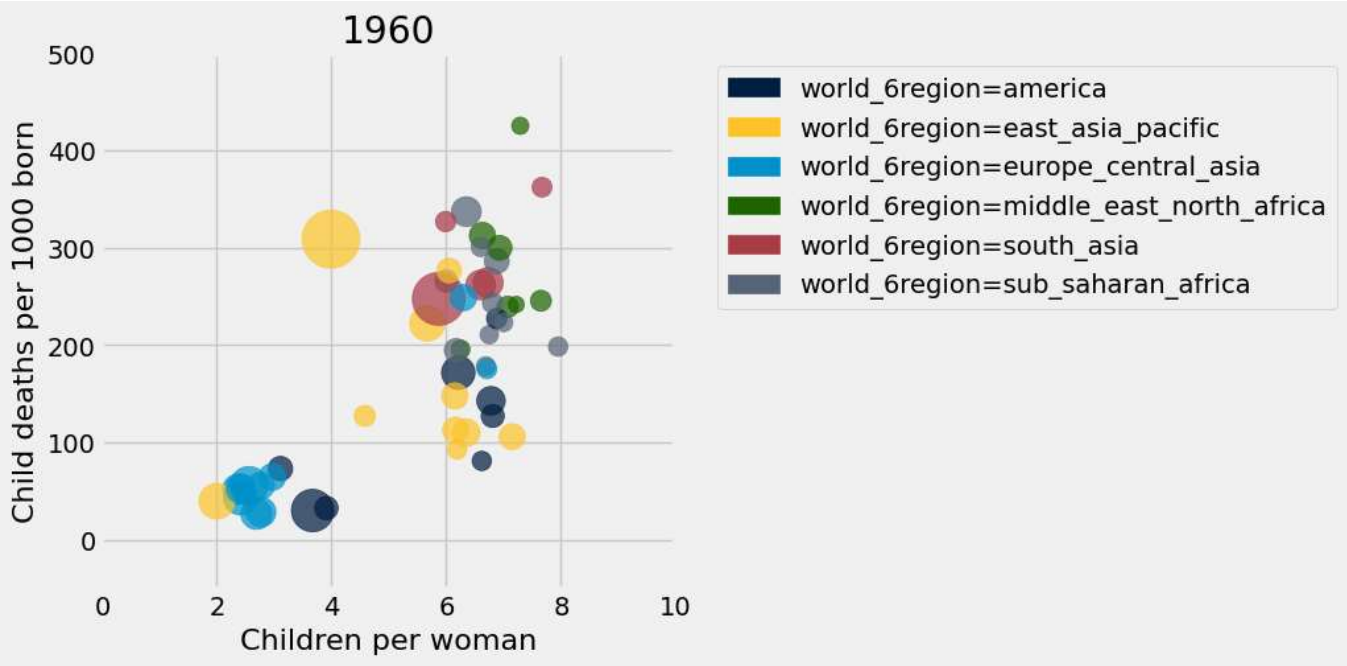
The following scatter diagram compares total fertility rate and child mortality rate for each country in 1960. The area of each dot represents the population of the country, and the color represents its region of the world. Run the cell. Do you think you can identify any of the dots?

```
from functools import lru_cache as cache

# This cache annotation makes sure that if the same year
# is passed as an argument twice, the work of computing
# the result is only carried out once.
@cache(None)
def stats_relabeled(year):
    """Relabeled and cached version of stats_for_year."""
    return stats_for_year(year).relabel(2, 'Children per woman').relabel(3, 'Child deaths pe

def fertility_vs_child_mortality(year):
    """Draw a color scatter diagram comparing child mortality and fertility."""
    with_region = stats_relabeled(year).join('geo', countries.select('country', 'world_6regi
    with_region.scatter(2, 3, sizes=1, group=4, s=500)
    plots.xlim(0,10)
    plots.ylim(-50, 500)
    plots.title(year)

fertility_vs_child_mortality(1960)
```



Question 14. Assign `scatter_statements` to an array of the numbers of each statement below that can be inferred from this scatter diagram for 1960.

1. As a whole, the `europe_central_asia` region had the lowest child mortality rate.
2. The lowest child mortality rate of any country was from an `east_asia_pacific` country.
3. Most countries had a fertility rate above 5.
4. There was an association between child mortality and fertility.
5. The two largest countries by population also had the two highest child mortality rate.

```
scatter_statements = {1,3,4}
```

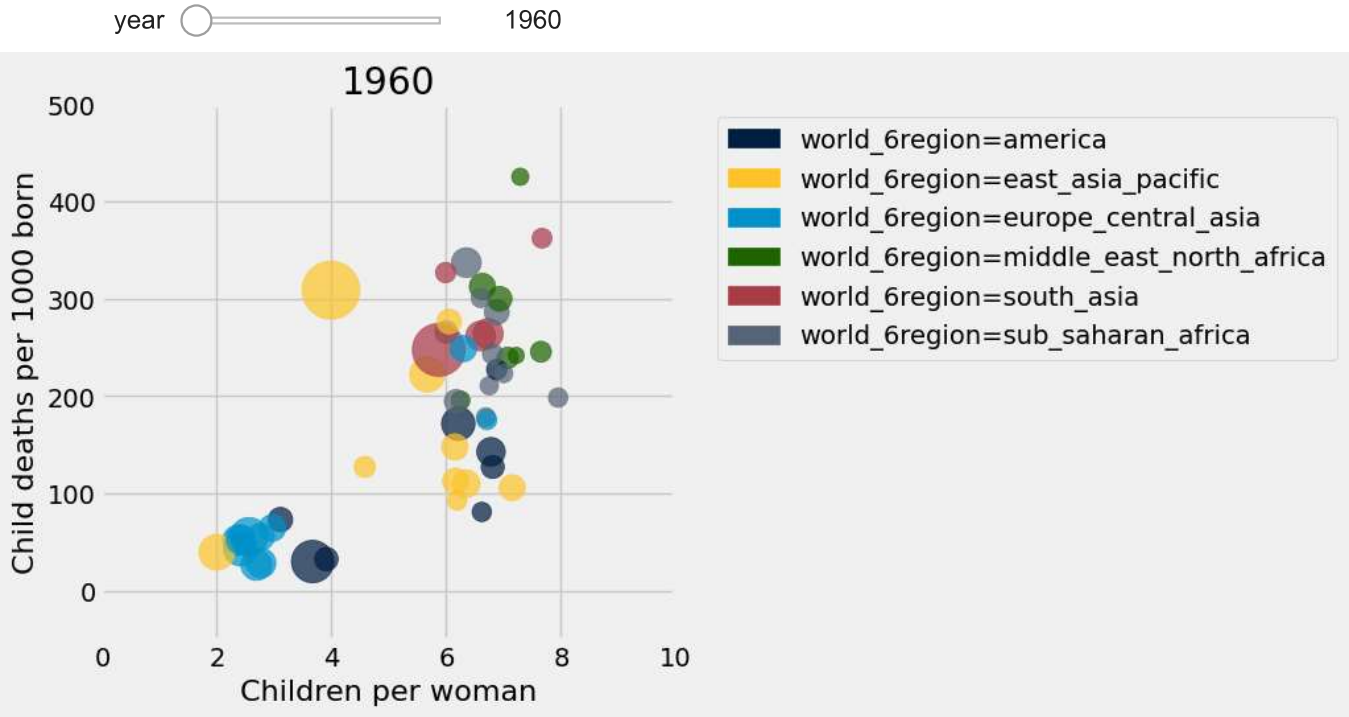
The result of the cell below is interactive. Drag the slider to the right to see how countries have changed over time. You'll find that the great divide between so-called "Western" and "developing" countries that existed in the 1960's has nearly disappeared. This shift in fertility rates is the reason that the global population is expected to grow more slowly in the 21st century than it did in the 19th and 20th centuries.

Note: Don't worry if a red warning pops up when running the cell below. You'll still be able to run the cell!

```
import ipywidgets as widgets

# This part takes a few minutes to run because it
# computes 55 tables in advance: one for each year.
Table().with_column('Year', np.arange(1960, 2016)).apply(stats_relabeled, 'Year')

_ = widgets.interact(fertility_vs_child_mortality,
                     year=widgets.IntSlider(min=1960, max=2015, value=1960))
```



Now is a great time to take a break and watch the same data presented by Hans Rosling in a 2010 TEDx talk with smoother animation and witty commentary.

2. Global Poverty

In 1800, 85% of the world's 1 billion people lived in *extreme poverty*, defined by the United Nations as "a condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information." A common measure of extreme poverty is a person living on less than $1.25 per day.

In 2018, the proportion of people living in extreme poverty was estimated to be 8%. Although the world rate of extreme poverty has declined consistently for hundreds of years, the number of people living in extreme poverty is still over 600 million. The United Nations recently adopted an ambitious goal: "By 2030, eradicate extreme poverty for all people everywhere." In this section, we will examine extreme poverty trends around the world.

First, load the population and poverty rate by country and year and the country descriptions. While the `population` table has values for every recent year for many countries, the `poverty` table only includes certain years for each country in which a measurement of the rate of extreme poverty was available.

```
population = Table.read_table('/content/drive/MyDrive/population.csv')
countries = Table.read_table('/content/drive/MyDrive/countries.csv').where('country', are.cc
poverty = Table.read_table('/content/drive/MyDrive/poverty.csv')
poverty.show(3)
```

geo	time	extreme_poverty_percent_people_below_125_a_day
alb	1996	0.2
alb	2002	0.73
alb	2004	0.53

... (1096 rows omitted)

Question 1. Assign `latest_poverty` to a three-column table with one row for each country that appears in the `poverty` table. The first column should contain the 3-letter code for the country. The second column should contain the most recent year for which an extreme poverty rate is available for the country. The third column should contain the poverty rate in that year. **Do not change the last line, so that the labels of your table are set correctly.**

Hint: think about how `group` works: it does a sequential search of the table (from top to bottom) and collects values in the array in the order in which they appear, and then applies a function to that array. The `first` function may be helpful, but you are not required to use it.

```
def first(values):
    return values.item(0)

a = (poverty.sort('geo').group('geo').column(1))

latest_poverty = poverty.sort('geo').take(np.cumsum(a) - 1)
latest_poverty = latest_poverty.relabeled(0, 'geo').relabeled(1, 'time').relabeled(2, 'pover
latest_poverty
```

geo	time	poverty_percent
ago	2009	43.37
alb	2012	0.46
arg	2011	1.41
arm	2012	1.75
aus	2003	1.36
aut	2004	0.34
aze	2008	0.31
bdi	2006	81.32
bel	2000	0.5
ben	2012	51.61

... (135 rows omitted)

Question 2. Using both `latest_poverty` and `population`, create a four-column table called `recent_poverty_total` with one row for each country in `latest_poverty`. The four columns should have the following labels and contents, in the following order:

1. `geo` contains the 3-letter country code,
2. `poverty_percent` contains the most recent poverty percent,
3. `population_total` contains the population of the country in 2010,
4. `poverty_total` contains the number of people in poverty **rounded to the nearest integer**, based on the 2010 population and most recent poverty rate.

```
population.sort('geo')
```

```
poverty_and_pop = (np.round(latest_poverty.drop(1).join('geo',population.where('time', are.e
recent_poverty_total = latest_poverty.drop(1).join('geo',population.where('time', are.equal_
recent_poverty_total
```

geo	poverty_percent	population_total	poverty_total
ago	43.37	21219954	9.20309e+06
alb	0.46	2901883	13349
arg	1.41	41222875	581243
arm	1.75	2963496	51861
aus	1.36	22162863	301415
aut	0.34	8391986	28533
aze	0.31	9099893	28210
bdi	81.32	9461117	7.69378e+06
bel	0.5	10929978	54650
ben	51.61	9509798	4.90801e+06

... (135 rows omitted)

Question 3. Assign the name `poverty_percent` to the known percentage of the world's 2010 population that were living in extreme poverty. Assume that the `poverty_total` numbers in the `recent_poverty_total` table describe **all** people in 2010 living in extreme poverty. You should find a number that is above the 2018 global estimate of 8%, since many country-specific poverty rates are older than 2018.

```
poverty_percent = (sum(recent_poverty_total.column(3)) / sum(population.where('time', are.ec
poverty_percent
```

```
14.299370218520854
```

The `countries` table includes not only the name and region of countries, but also their positions on the globe.

```
countries.select('country', 'name', 'world_4region', 'latitude', 'longitude')
```

country	name	world_4region	latitude	longitude
afg	Afghanistan	asia	33	66
akr_a_dhe	Akrotiri and Dhekelia	europe	nan	nan
alb	Albania	europe	41	20
dza	Algeria	africa	28	3
asm	American Samoa	asia	-11.056	-171.082
and	Andorra	europe	42.5078	1.52109
ago	Angola	africa	-12.5	18.5
aia	Anguilla	americas	18.2167	-63.05
atg	Antigua and Barbuda	americas	17.05	-61.8
arg	Argentina	americas	-34	-64

... (245 rows omitted)

Question 4. Using both `countries` and `recent_poverty_total`, create a five-column table called `poverty_map` with one row for every country in `recent_poverty_total`. The five columns should have the following labels and contents:

1. `latitude` contains the country's latitude,
2. `longitude` contains the country's longitude,
3. `name` contains the country's name,
4. `region` contains the country's region from the `world_4region` column of `countries`,
5. `poverty_total` contains the country's poverty total.

```
poverty_map = recent_poverty_total.drop(1,2).join('geo',countries.select('country', 'name',

poverty_map
```

geo	poverty_total	name	world_4region	latitude	longitude
ago	9.20309e+06	Angola	africa	-12.5	18.5
alb	13349	Albania	europe	41	20
arg	581243	Argentina	americas	-34	-64
arm	51861	Armenia	europe	40.25	45
aus	301415	Australia	asia	-25	135
aut	28533	Austria	europe	47.3333	13.3333
aze	28210	Azerbaijan	europe	40.5	47.5
bdi	7.69378e+06	Burundi	africa	-3.5	30
bel	54650	Belgium	europe	50.75	4.5
ben	4.90801e+06	Benin	africa	9.5	2.25

... (135 rows omitted)

Run the cell below to draw a map of the world in which the areas of circles represent the number of people living in extreme poverty. Double-click on the map to zoom in.

```
# It may take a few seconds to generate this map.
colors = {'africa': 'blue', 'europe': 'black', 'asia': 'red', 'americas': 'green'}
scaled = poverty_map.with_columns(
    'poverty_total', 1e-4 * poverty_map.column('poverty_total'),
    'world_4region', poverty_map.apply(colors.get, 'world_4region')
)
Circle.map_table(scaled)
```

```
---------------------------------------------------------------------------
AssertionError                            Traceback (most recent call last)
<ipython-input-93-9369a89cbc8b> in <cell line: 7>()
      5     'world_4region', poverty_map.apply(colors.get, 'world_4region')
      6 )
----> 7 Circle.map_table(scaled)

 4 frames 

/usr/local/lib/python3.10/dist-packages/datascience/maps.py in map_table(cls, table,
clustered_marker, include_color_scale_outliers, radius_in_meters, **kwargs)
    745         if not other_attrs:
    746             other_attrs = None
--> 747         return cls.map(
    748             latitudes=lat, longitudes=lon, labels=lab, colors=color,
areas=areas,
    749             colorbar_scale=colorbar_scale, other_attrs=other_attrs,
clustered_marker=clustered_marker,

/usr/local/lib/python3.10/dist-packages/datascience/maps.py in map(cls, latitudes,
longitudes, labels, colors, areas, other_attrs, clustered_marker, **kwargs)
    650
    651         if other_attrs_processed:
--> 652             ms = [cls(*args, **other_attrs_processed[row_num]) for row_num,
args in enumerate(zip(*inputs))]
    653         else:
    654             ms = [cls(*args, **kwargs) for row_num, args in
enumerate(zip(*inputs))]

/usr/local/lib/python3.10/dist-packages/datascience/maps.py in <listcomp>(.0)
    650
    651         if other_attrs_processed:
--> 652             ms = [cls(*args, **other_attrs_processed[row_num]) for row_num,
args in enumerate(zip(*inputs))]
    653         else:
    654             ms = [cls(*args, **kwargs) for row_num, args in
enumerate(zip(*inputs))]

/usr/local/lib/python3.10/dist-packages/datascience/maps.py in __init__(self, lat, lon,
popup, color, area, **kwargs)
    800             warnings.warn("The 'radius' argument is deprecated. Please use
'area' instead.", FutureWarning)
    801             radius = kwargs.pop('radius')
--> 802         super().__init__(lat, lon, popup, color, radius=radius, **kwargs)
    803
    804     @property
```

Next steps: Explain error

Although people live in extreme poverty throughout the world (with more than 5 million in the United States), the largest numbers are in Asia and Africa.

Question 5. Assign `largest` to a two-column table with the `name` (not the 3-letter code) and `poverty_total` of the 10 countries with the largest number of people living in extreme poverty.

```
largest = poverty_map.sort('poverty_total', descending = True).take(np.arange(0,10)).drop(0,
largest.set_format('poverty_total', NumberFormatter)
```

poverty_total	name
290,881,638.00	India
98,891,167.00	Nigeria
83,944,643.00	China
65,574,256.00	Bangladesh
57,841,438.00	Congo, Dem. Rep.
39,141,326.00	Indonesia
32,213,991.00	Ethiopia
21,663,595.00	Pakistan
19,847,979.00	Tanzania
18,480,426.00	Madagascar

Question 6. Write a function called `poverty_timeline` that takes **the name of a country** (not the geo code) as its argument. It should draw a line plot of the number of people living in poverty in that country with time on the horizontal axis. The line plot should have a point for each row in the `poverty` table for that country. To compute the population living in poverty from a poverty percentage, multiply by the population of the country **in that year**.

Hint: To make your plot, you will first need to make a table.

Hint: This question is long. Feel free to create cells and experiment.

```
def poverty_timeline(country):
    '''Draw a timeline of people living in extreme poverty in a country.'''

    # This solution will take multiple lines of code. Use as many as you need
    geo = poverty_map.where('name', are.equal_to(country)).column(0)
    cty = poverty.where('geo',are.equal_to(geo)).column(1)


    t = population.where('geo',are.equal_to(geo)).join('time',poverty.where('geo',are.equal_



    country_poverty = t.column(2) * t.column(4) / 100
    timetable = poverty.where('geo',are.equal_to(geo)).with_column('country_poverty', countr
    return timetable.plot('time','country_poverty')
```

Finally, draw the timelines below to see how the world is changing. You can check your work by comparing your graphs to the ones on gapminder.org.

```
poverty_timeline('India')
poverty_timeline('Nigeria')
poverty_timeline('China')
poverty_timeline('United States')
```