World Progress

In this project, you'll explore data from Gapminder.org (http://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 (https://github.com/open-numbers/ddf--gapminder--systema_globalis/blob/master/README.md). 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.

This project is dedicated to Hans Rosling (https://en.wikipedia.org/wiki/Hans_Rosling) (1948-2017), who championed the use of data to understand and prioritize global development challenges.

Logistics

Deadline. This project is due at 11:59pm on Friday 9/28. Projects will be accepted up to 2 days (48 hours) late; a project submitted less than 24 hours after the deadline will receive 2/3 credit, a project submitted between 24 and 48 hours after the deadline will receive 1/3 credit, and a project submitted 48 hours or more after the deadline will receive no credit. It's **much** better to be early than late, so start working now.

Checkpoint. For full credit, you must also complete the first 8 questions and submit them by 11:59pm on Friday 9/21. You will have some lab time to work on these questions, but we recommend that you start the project before lab and leave time to finish the checkpoint afterward.

Partners. You may work with one other partner; your partner must be from your assigned lab section. Only one of you is required to submit the project. On okpy.org (http://okpy.org), the person who submits should also designate their partner so that both of you receive credit.

Rules. Don't share your code with anybody but your partner. You are welcome to discuss questions with other students, but don't share the answers. The experience of solving the problems in this project will prepare you for exams (and life). If someone asks you for the answer, resist! Instead, you can demonstrate how you would solve a similar problem.

Support. You are not alone! Come to office hours, post on Piazza, and talk to your classmates. If you want to ask about the details of your solution to a problem, make a private Piazza post and the staff will respond. If you're ever feeling overwhelmed or don't know how to make progress, email your TA or tutor for help. You can find contact information for the staff on the course website (http://data8.org/fa18/staff.html).

Tests. The tests that are given are **not comprehensive** and passing the tests for a question **does not** mean that you answered the question correctly. Tests usually only check that your table has the correct column labels. However, more tests will be applied to verify the correctness of your submission in order to assign your final score, so be careful and check your work! You might want to create your own checks along the way to see if your answers make sense. Additionally, before you submit, make sure that none of your cells take a very long time to run (several minutes).

Free Response Questions: Make sure that you put the answers to the written questions in the indicated cell we provide. Check to make sure that you have a Gradescope (http://gradescope.com) account, which is where the scores to the free response questions will be posted. If you do not, make sure to reach out to your assigned (u)GSI.

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`.

In [1]:
```
from datascience import *
import numpy as np

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

from client.api.notebook import Notebook
ok = Notebook('project1.ok')
_ = ok.auth(inline=True)
```

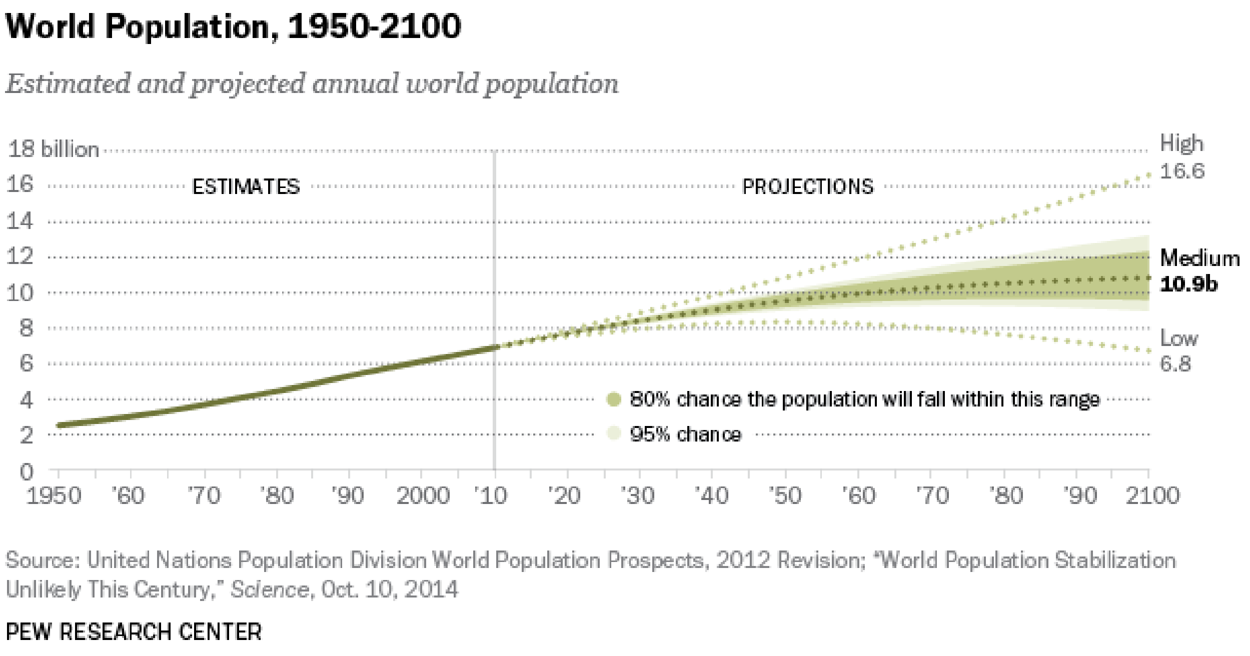
```
=====================================================================
Assignment: World Progress
OK, version v1.12.5
=====================================================================

Successfully logged in as jessicarodriguez@berkeley.edu
```

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.



(http://www.pewresearch.org/fact-tank/2015/06/08/scientists-more-worried-than-public-about-worlds-growing-population/ft_15-06-04_popcount/)

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.

In [2]:
```
population = Table.read_table('population.csv')
population.show(3)
```

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

... (87792 rows omitted)

Note: The population csv file can also be found here (https://github.com/open-numbers/ddf--gapminder--systema_globalis/raw/master/ddf--datapoints--population_total--by--geo--time.csv). 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 (https://en.wikipedia.org/wiki/International_Organization_for_Standardization) (ISO) in the Alpha-3 (https://en.wikipedia.org/wiki/ISO_3166-1_alpha-3#Current_codes) 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.

In [3]:
```
bgd = Table()


bgd_pop_1970_to_2015 = population.where('time', are.between_or_equal_to(197
len(bgd_pop_1970_to_2015)



b_pop = bgd.with_columns("time",np.arange(1970,2016,1),"population_total",
b_pop.show()
```

time	population_total
1970	65048701
1971	66417450
1972	67578486
1973	68658472
1974	69837960
1975	71247153
1976	72930206
1977	74848466
1978	76948378
1979	79141947
1980	81364176
1981	83599582
1982	85868228
1983	88181211
1984	90559540
1985	93015182
1986	95550798
1987	98149262
1988	100779551
1989	103400571
1990	105983136
1991	108509679
1992	110987459
1993	113442354
1994	115913710
1995	118427768
1996	120987124
1997	123574107
1998	126169583

time	population_total
1999	128746273
2000	131280739
2001	133776064
2002	136228456
2003	138600174
2004	140843786
2005	142929979
2006	144839238
2007	146592687
2008	148252473
2009	149905836
2010	151616777
2011	153405612
2012	155257387
2013	157157394
2014	159077513
2015	160995642

In [4]:
```
_ = ok.grade('q1_1')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 3
    Failed: 0
[ooooooooook] 100.0% passed
```

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!

In [5]:
```
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
```

Out[5]:

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 `b_1970_through_2010` to a table that has the same columns as `b_five` and has one row for every five years from 1970 through 2010 (but not 2015). Then, use that table to assign `initial` to an array that contains the population for every five year interval from 1970 to 2010. Finally, assign `changed` to an array that contains the population for every five year interval from 1975 to 2015.

Hint: You may find the `exclude` method to be helpful (Docs (http://data8.org/datascience/_autosummary/datascience.tables.Table.exclude.html)).

In [6]:
```
b_1970_through_2010 = b_five.exclude(9)


initial = b_1970_through_2010.column('population_total')


changed = b_five.exclude(0).column('population_total')
```

We have provided the code below that uses `b_1970_through_2010` , `initial` , and `changed` in order to add a column to the table called `annual_growth` . Don't worry about the calculation of the growth rates; run the test below to test your solution.

If you are interested in how we came up with the formula for growth rates, consult the growth rates (https://www.inferentialthinking.com/chapters/03/2/1/growth) section of the textbook.

In [7]:
```
b_five_growth = b_1970_through_2010.with_column('annual_growth', (changed/i
b_five_growth.set_format('annual_growth', PercentFormatter)
```

Out[7]:

time	population_total	annual_growth
1970	65,048,701	1.84%
1975	71,247,153	2.69%
1980	81,364,176	2.71%
1985	93,015,182	2.64%
1990	105,983,136	2.25%
1995	118,427,768	2.08%
2000	131,280,739	1.71%
2005	142,929,979	1.19%
2010	151,616,777	1.21%

In [8]:
```
_ = ok.grade('q1_2')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 4
    Failed: 0
[ooooooooook] 100.0% passed
```

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.

In [9]:
```
life_expectancy = Table.read_table('life_expectancy.csv')
child_mortality = Table.read_table('child_mortality.csv').relabeled(2, 'chi
fertility = Table.read_table('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 (http://blogs.worldbank.org/opendata/what-does-life-expectancy-birth-really-mean). 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!

In [10]:
```
life_expectancy
```

Out[10]:

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)

In [11]:
```
child_mortality
```

Out[11]:

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)

In [12]:
```
fertility
```

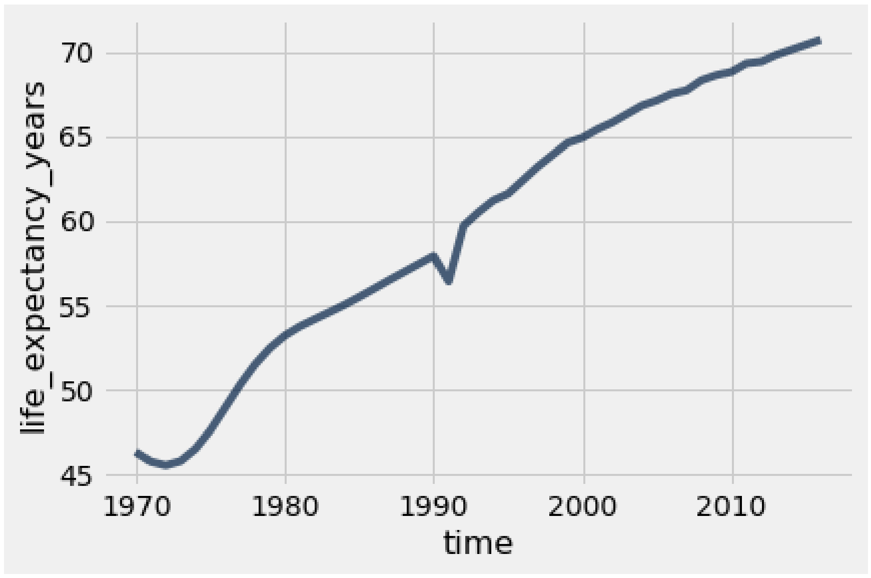
Out[12]:

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.

In [13]:
```
new_L_E = life_expectancy.where('geo', are.equal_to('bgd')).where('time', a
new_L_E.plot('time','life_expectancy_years')
```



Question 4. Assuming everything else stays the same, does the graph above help directly explain why the population growth rate decreased from 1985 to 2010 in Bangladesh? Why or why not? What happened in Bangladesh in 1991, and does that event explain the change in population growth rate?

The graph above doesn't help directly explain why the population growth rate decreased from 1985 to 2010 in Bangladesh because by looking at the trend of the graph, the rate is increasing from this time perioed (excluding the drop around 1991). This doesn't really tell us why the population growth rate is decreasing. In 1991, Bangladesh suffered one of the worst and catastrophic cyclones in their history, killing over 130,000 people and causing over $1.3 billion in damage. In the graph, this impact in the population is represented by a sudden drop in life_expectancy_years around 1991.

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 (https://www.measureevaluation.org/prh/rh_indicators/specific/fertility/total-fertility-rate)](https://www.measureevaluation.org/prh/rh_indicators/specific/fertility/total-fertility-rate), 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.

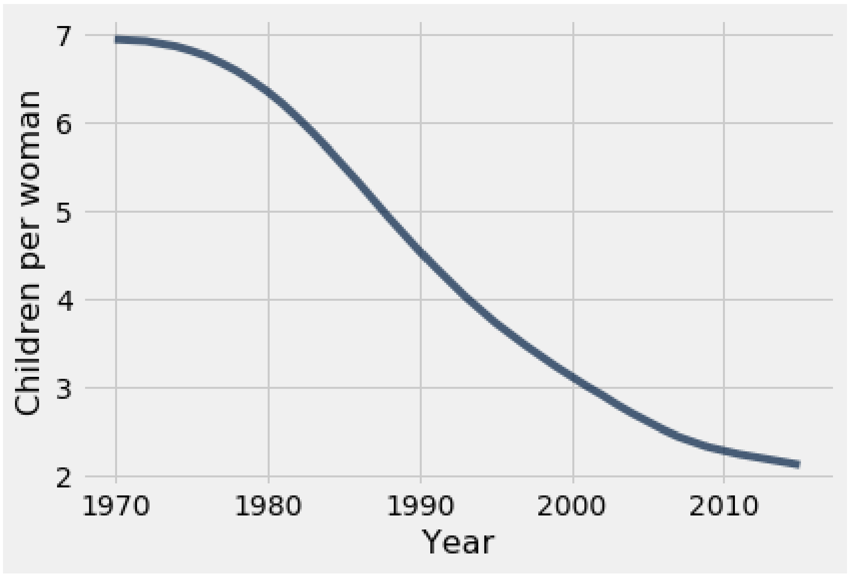
Question 5. Write a function `fertility_over_time` that takes the Alpha-3 code of a `country` and a `start` year. It returns a two-column table with labels " `Year` " and " `Children per woman` " that can be used to generate a line chart of the country's fertility rate each year, starting at the `start` 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.**

In [14]:
```
def fertility_over_time(country, start):
    """Create a two-column table that describes a country's total fertility
    country_fertility = fertility.where('geo', are.equal_to(country))
    country_fertility_after_start = country_fertility.where('time', are.abc
    return country_fertility_after_start.drop('geo').relabeled('time','Year

#def fertility_over_time(country, start):
    """Create a two-column table that describes a country's total fertility
```

In [15]:
```
bangladesh_code = 'bgd'
fertility_over_time(bangladesh_code, 1970).plot(0, 1) # You should *not* ch
```



```
In [16]: _ = ok.grade('q1_5')
```

```
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Running tests

---------------------------------------------------------------------
Test summary
    Passed: 2
    Failed: 0
[ooooooooook] 100.0% passed
```

Question 6. Assuming everything else stays the same, does the graph above help directly explain why the population growth rate decreased from 1985 to 2010 in Bangladesh? Why or why not?

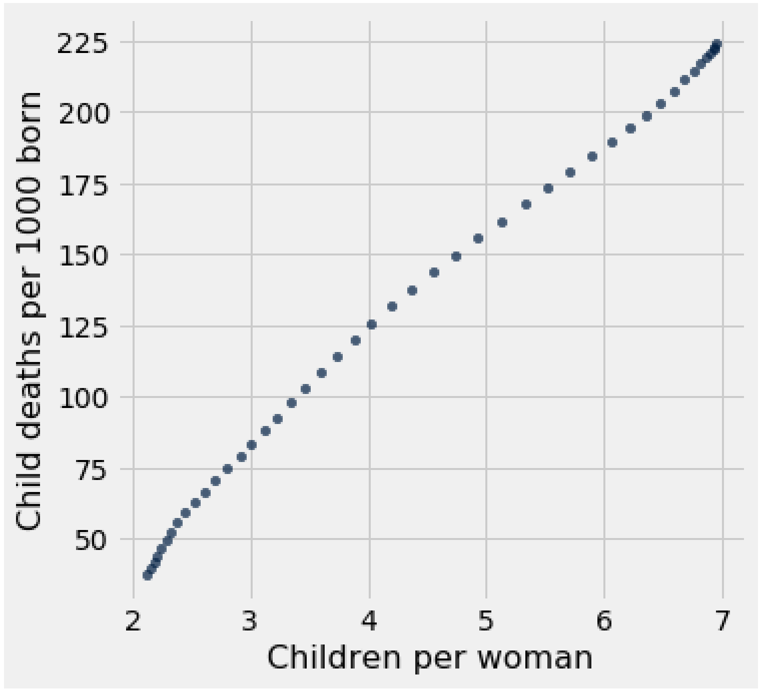
Yes, the graph above helps explain why the population growth rate decreased from 1985 to 2010 in Bangladesh because it shows a steep decrease in the total fertility rate for those corresponding years. This means that the total amount of babies being born in Bangladesh has lowered drastically and that is a primary contributor to decreasing population growth rates.

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 (https://en.wikipedia.org/wiki/Child_mortality).

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

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.

In [17]:
```
bgd_fertility = fertility.where('geo', are.equal_to('bgd')).select('time','
bgd_child_mortality = child_mortality.where('geo', are.equal_to('bgd')).sel
#bgd_child_mortality
fertility_and_child_mortality = bgd_child_mortality.join('time',bgd_fertili
fertility_and_child_mortality
post_1969_fertility_and_child_mortality = fertility_and_child_mortality.whe
post_1969_fertility_and_child_mortality.scatter('Children per woman', 'Chil
```



In [18]:
```
_ = ok.grade('q1_7')
```

```
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Running tests

---------------------------------------------------------------------
Test summary
    Passed: 2
    Failed: 0
[ooooooooook] 100.0% passed
```

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?

There is an association between the more deaths per 1000 born and children per woman because of the evident positive correlation within the scatter diagram. The diagram does show that reduced child mortality causes parents to choose to have fewer children because the fewer the child deaths occur, the less children are born which proves that parents are choosing to have fewer children.

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.

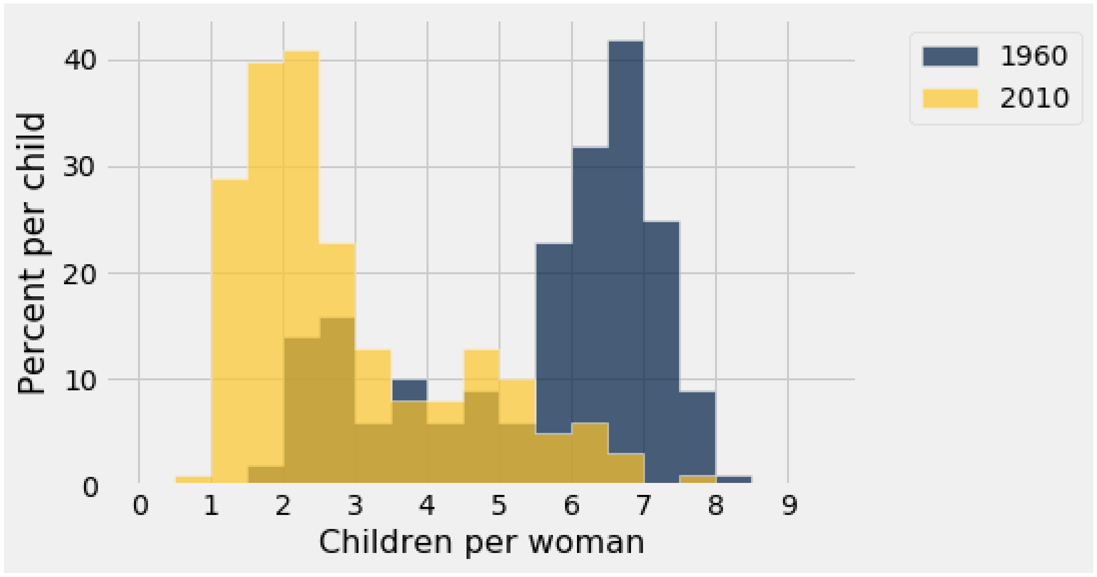
In [19]:
```
fertility
```

Out[19]:

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)

In [20]:
```
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')
_ = plots.xlabel('Children per woman')
_ = plots.xticks(np.arange(10))
```



Question 9. Assign `fertility_statements` to a list 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 (inclusive).
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 (inclusive) in 1960.
6. At least half of countries had a fertility rate below 3 in 2010.

```
In [21]: fertility_statements = [1, 3, 4, 5, 6]
```

```
In [22]: _ = ok.grade('q1_9')
```

```
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Running tests

---------------------------------------------------------------------
Test summary
    Passed: 1
    Failed: 0
[ooooooooook] 100.0% passed
```

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.

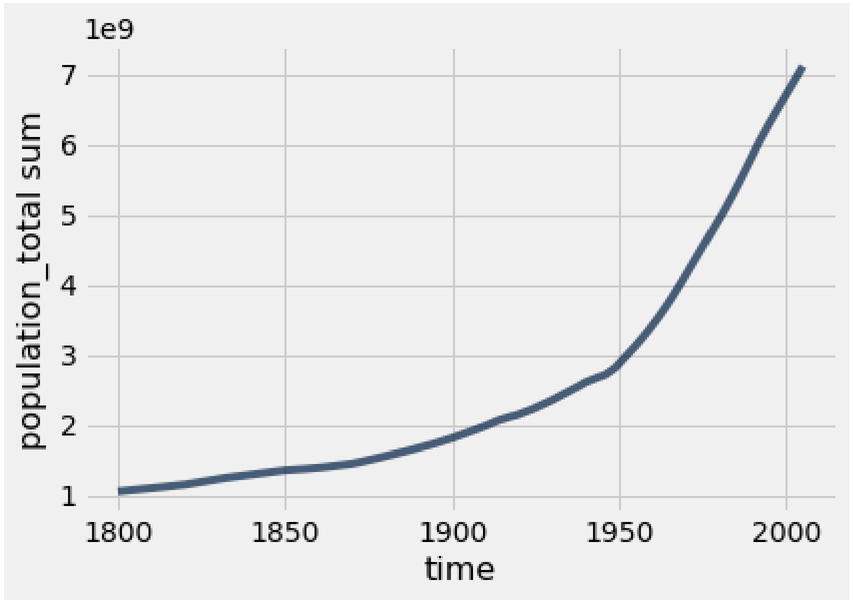
```
In [23]: population
```

Out[23]:

geo	time	population_total
abw	1800	19286
abw	1801	19286
abw	1802	19286
abw	1803	19286
abw	1804	19286
abw	1805	19286
abw	1806	19286
abw	1807	19286
abw	1808	19286
abw	1809	19286

... (87785 rows omitted)

In [24]:
```
population.where('time', are.between(1800, 2006)).group('time',sum).plot('t
```



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.

Hint: The tests for this question are quite comprehensive, so if you pass the tests, your function is probably correct. However, without calling your function yourself and looking at the output, it will be very difficult to understand any problems you have, so try your best to write the function correctly and check that it works before you rely on the `ok` tests to confirm your work.

In [25]:
```
# 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', 2010).sort(2, descending=True).take(np.ar
population_of_big_50 = population.where('time', are.above(1959)).where('gec



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

    return p_f_n_c
```

Try calling your function `stats_for_year` on any year between 1960 and 2010 in the cell below. Try to understand the output of `stats_for_year`.

In [26]:
```
stats_for_year(2000)
```

Out[26]:

geo	population_total	children_per_woman_total_fertility	child_mortality_under_5_per_1000_born
afg	19701940	7.73	137
arg	37057453	2.48	20.2
bgd	131280739	3.12	88
bra	175786441	2.36	32.4
can	30701903	1.51	6.2
chn	1269974572	1.45	36.9
cod	48048664	7.09	161
col	40403959	2.64	25.1
deu	81895925	1.35	5.4
dza	31183658	2.51	39.7

... (40 rows omitted)

In [27]:
```
_ = ok.grade('q1_11')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 4
    Failed: 0
[ooooooooook] 100.0% passed
```

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.

Note: The `pop_by_decade` cell is directly below the cell containing the helper function `pop_for_year`. This is where you will generate the `pop_by_decade` table!

In [28]:
```
def pop_for_year(year):
    pop_total = sum(stats_for_year(year).column('population_total'))
    return pop_total
```

This 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` .

```
In [29]: _ = ok.grade('q1_12_0')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 1
    Failed: 0
[ooooooooook] 100.0% passed
```

```
In [30]: decades = Table().with_column('decade', np.arange(1960, 2011, 10))

         pop_by_decade = decades.with_column('population', decades.apply(pop_for_yea
         pop_by_decade.set_format(1, NumberFormatter)
```

Out[30]:

decade	population
1960	2,624,944,597
1970	3,211,487,418
1980	3,880,722,003
1990	4,648,434,558
2000	5,367,553,063
2010	6,040,810,517

```
In [31]: _ = ok.grade('q1_12')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 2
    Failed: 0
[ooooooooook] 100.0% passed
```

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.

In [32]:
```
countries = Table.read_table('countries.csv').where('country', are.containe
countries.select('country', 'name', 'world_6region')
```

Out[32]:

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 describe the count of how many countries in each region 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.

In [ ]:
```

```

In [33]:
```
stats_for_year(1960)
```

Out[33]:

geo	population_total	children_per_woman_total_fertility	child_mortality_under_5_per_1000_born
afg	8994793	7.67	362.4
arg	20619075	3.11	73.2
bgd	48200702	6.73	264.3
bra	72493585	6.21	171.8
can	17909232	3.91	32.6
chn	644450173	3.99	309
cod	15248246	6	266
col	16480384	6.81	127.3
deu	73179665	2.41	42.87
dza	11124892	7.65	245.7

... (40 rows omitted)

In [34]:
```
countries_bit = countries.select('country', 'name', 'world_6region')
region_counts = stats_for_year(1960).join('geo', countries_bit, 'country').
region_counts
```

Out[34]:

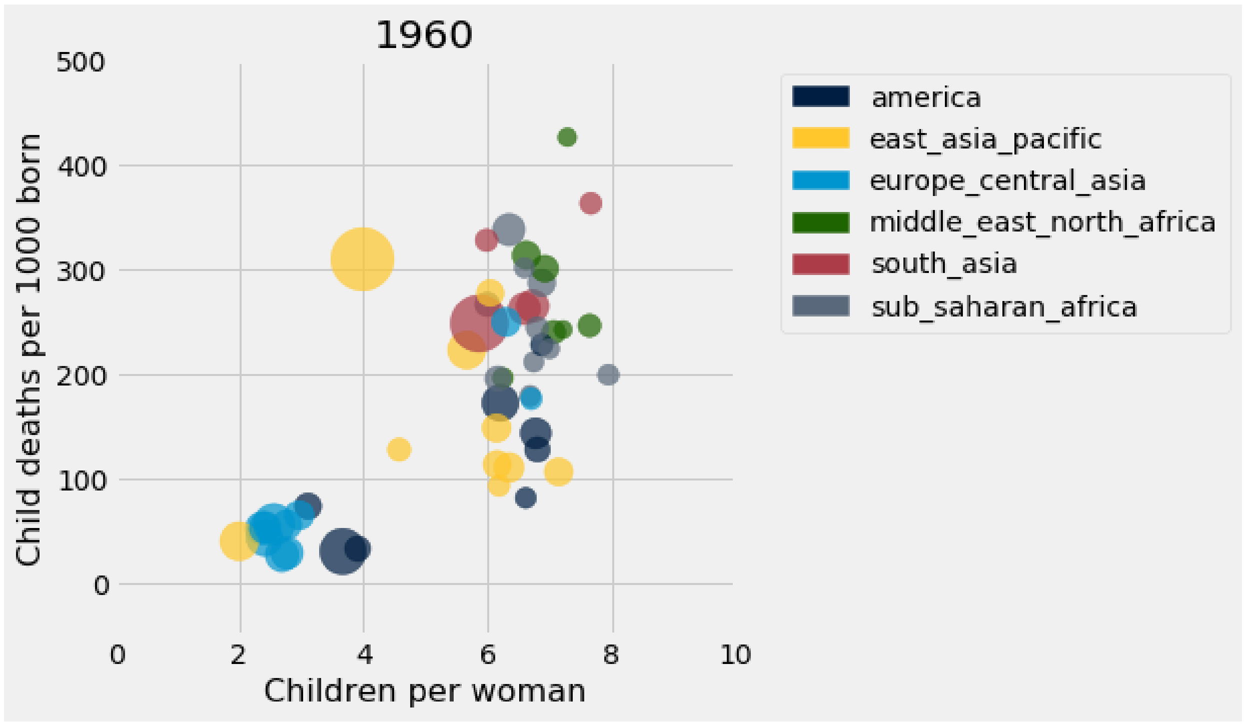
region	count
america	8
east_asia_pacific	10
europe_central_asia	10
middle_east_north_africa	7
south_asia	5
sub_saharan_africa	10

In [35]:
```
_ = ok.grade('q1_13')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 2
    Failed: 0
[ooooooooook] 100.0% passed
```

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?

In [36]:
```
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).relabeled(2, 'Children per woman').relabele

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('count
    with_region.scatter(2, 3, sizes=1, colors=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 a list of the numbers of each statement below that can be inferred from this scatter diagram for 1960.

1. The `europe_central_asia` region had the lowest child mortality rate.
2. The lowest child mortality rate of any country was from an `east_asian_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.

In [37]:
```
scatter_statements = [1, 3, 4]
```

```
In [38]: _ = ok.grade('q1_14')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 1
    Failed: 0
[ooooooooook] 100.0% passed
```

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.

```
In [192]: 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, '

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

```
/srv/app/venv/lib/python3.6/site-packages/datascience/tables.py:192: Futu
reWarning: Implicit column method lookup is deprecated.
  warnings.warn("Implicit column method lookup is deprecated.", FutureWar
ning)
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

Now is a great time to take a break and watch the same data presented by Hans Rosling in a 2010 TEDx talk (https://www.gapminder.org/videos/reducing-child-mortality-a-moral-and-environmental-imperative) 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 (http://www.un.org/sustainabledevelopment/poverty/): "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.

In [39]:
```
population = Table.read_table('population.csv')
countries = Table.read_table('countries.csv').where('country', are.containe
poverty = Table.read_table('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_poverty_total 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.

In [54]:
```
def first(values):
    return values.item(0)

latest_poverty = poverty.sort('time', descending = True).group('geo', first
latest_poverty.relabel(0, 'geo').relabel(1, 'time').relabel(2, 'poverty_per
```

Out[54]:

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)

In [55]:
```
_ = ok.grade('q2_1')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 2
    Failed: 0
[ooooooooook] 100.0% passed
```

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:

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.

In [58]:
```
latest_poverty
```

Out[58]:

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)

In [85]:
```
pop = population.where('time', are.equal_to(2010))
poverty_and_pop = latest_poverty.join('geo', pop).drop('time_2').drop('time

poverty_rate = np.round(((poverty_and_pop.column('poverty_percent')*.01)*(p

recent_poverty_total = poverty_and_pop.with_column('poverty_total', poverty
recent_poverty_total
```

Out[85]:

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)

In [86]:
```
_ = ok.grade('q2_2')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 3
    Failed: 0
[ooooooooook] 100.0% passed
```

Question 3. Assuming that the `poverty_total` numbers in the `recent_poverty_total` table describe *all* people in 2010 living in extreme poverty, assign the name `poverty_percent` to the percentage of the world's 2010 population that were 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.

Hint: The sum of the `population_total` column in the `recent_poverty_total` table is not the world population, because only a subset of the world's countries have known poverty rates. Use the `population` table to compute the world's 2010 total population.

In [88]:
```
poverty_percent = (sum(recent_poverty_total.column('poverty_total'))/sum(re
poverty_percent
```

Out[88]:
```
15.072771327021862
```

In [89]:
```
_ = ok.grade('q2_3')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 1
    Failed: 0
[ooooooooook] 100.0% passed
```

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

In [91]:
```
countries.select('country', 'name', 'world_4region', 'latitude', 'longitude
```

Out[91]:

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 four 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.

In [99]:
```
poverty_map_pt1 = countries.join('country', recent_poverty_total, 'geo').se
poverty_map = poverty_map_pt1.relabeled('world_4region', 'region')
poverty_map
```

Out[99]:

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

... (135 rows omitted)

In [100]:
```
_ = ok.grade('q2_4')
```

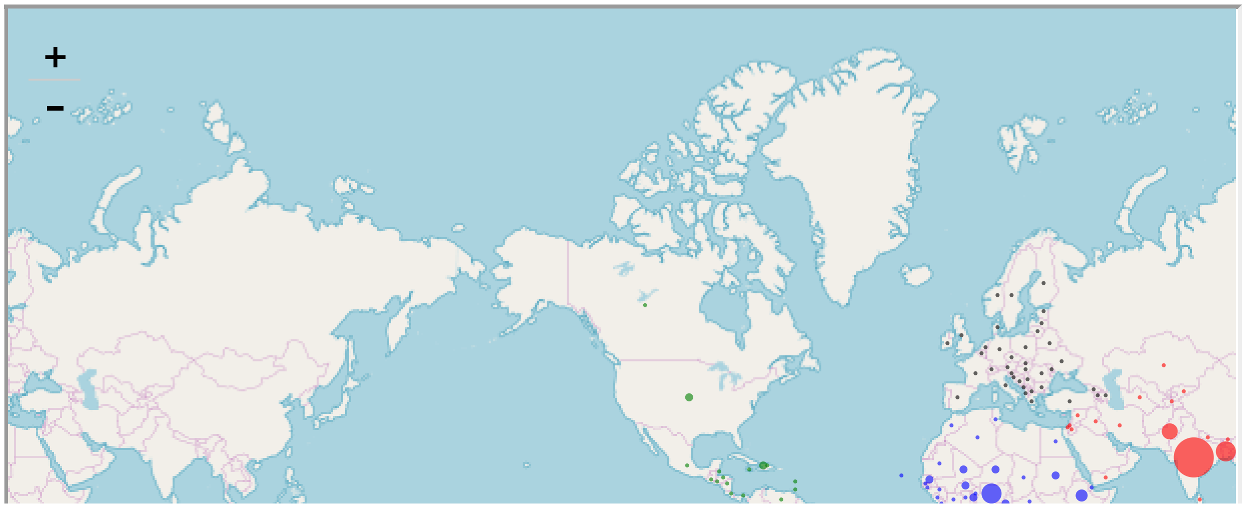
```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 2
    Failed: 0
[ooooooooook] 100.0% passed
```

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.

In [101]:
```
# It may take a few seconds to generate this map.
colors = {'africa': 'blue', 'europe': 'black', 'asia': 'red', 'americas': '
scaled = poverty_map.with_column(
    'poverty_total', 2e4 * poverty_map.column('poverty_total'),
    'region', poverty_map.apply(colors.get, 'region')
)
Circle.map_table(scaled)
```

```
/srv/app/venv/lib/python3.6/site-packages/datascience/maps.py:368: Future
Warning: circle_marker is deprecated. Use add_children(CircleMarker) inst
ead
  f(**self._folium_kwargs)
```

Out[101]:



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.

In [106]:
```
largest = poverty_map.sort('poverty_total', descending = True).select('name
largest
```

Out[106]:

name	poverty_total
India	2.90882e+08
Nigeria	9.88912e+07
China	8.39446e+07
Bangladesh	6.55743e+07
Congo, Dem. Rep.	5.78414e+07
Indonesia	3.91413e+07
Ethiopia	3.2214e+07
Pakistan	2.16636e+07
Tanzania	1.9848e+07
Madagascar	1.84804e+07

In [107]:
```
_ = ok.grade('q2_5')
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Running tests

---------------------------------------------------------------------
Test summary
    Passed: 3
    Failed: 0
[ooooooooook] 100.0% passed
```

Question 6. Write a function called `poverty_timeline` that takes **the name of a country** 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: The names within the `poverty_timeline` function correspond to our staff solution, but you don't need to use them. Any way that you want to draw the plot is fine, as long as it generates the correct graph.

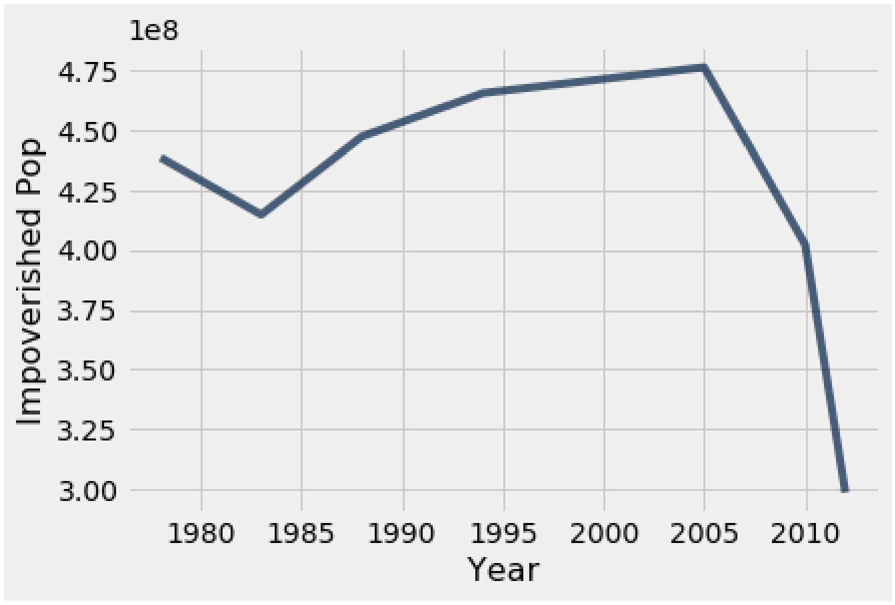
Hint: For the `apply` method, if you don't specify a particular column to apply your function on, the whole row is used as an input to the function. Elements inside a row can be accessed using `.item`.

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

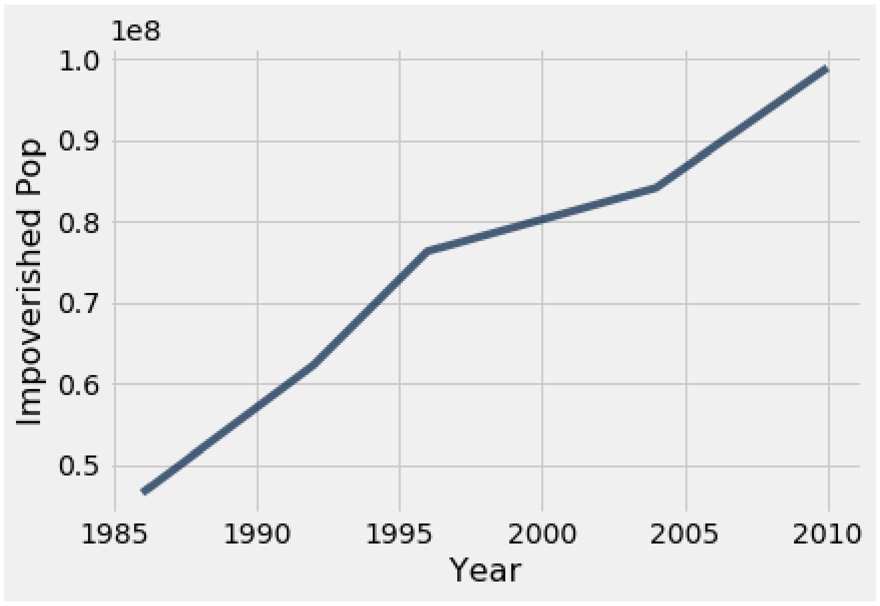
In [199]:
```
def population_for_country_in_year(row_of_poverty_table):
    """Optional: Define a function to return the population
    of a country in a year using a row from the poverty table."""
    population_country_tbl = population.where(
        'time', row_of_poverty_table.item('time')).where('geo', row_of_pove
    return population_country_tbl.column('population_total').item(0)

def poverty_timeline(country):
    """Draw a timeline of people living in extreme poverty in a country."""
    geo = new_pov.where('name', are.equal_to(country)).column('geo').item(0
    country_poverty = poverty.where('geo', are.equal_to(geo)).relabeled('ex
    poverty_population_tbl =Table().with_columns('Year', country_poverty.cc
    return poverty_population_tbl.plot('Year', 'Impoverished Pop')
```

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 (https://goo.gl/lPujuh).

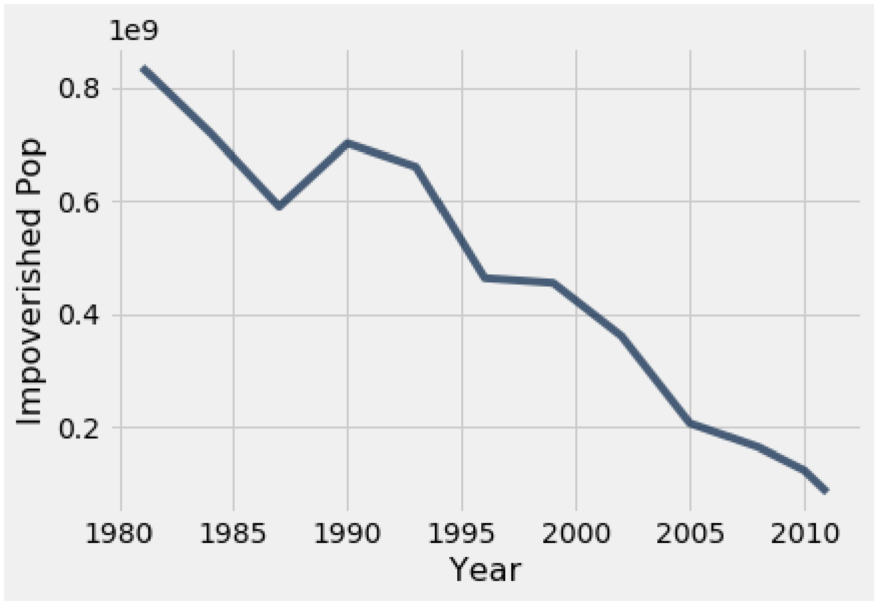
In [198]:
```
poverty_timeline('India')
```



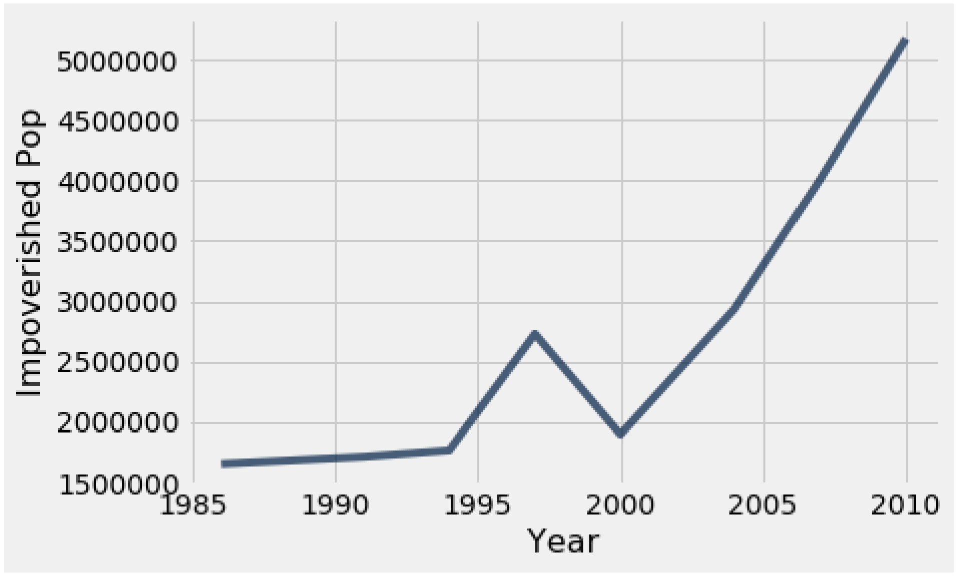
In [188]:
```
poverty_timeline('Nigeria')
```



In [189]:
```
poverty_timeline('China')
```



In [190]:
```
poverty_timeline('United States')
```



Although the number of people living in extreme poverty has been increasing in Nigeria and the United States, the massive decreases in China and India have shaped the overall trend that extreme poverty is decreasing worldwide, both in percentage and in absolute number.

To learn more, watch [Hans Rosling in a 2015 film (https://www.gapminder.org/videos/dont-panic-end-poverty/)](https://www.gapminder.org/videos/dont-panic-end-poverty/) about the UN goal of eradicating extreme poverty from the world.

Below, we've also added an interactive dropdown menu for you to visualize `poverty_timeline` graphs for other countries. Note that each dropdown menu selection may take a few seconds to run.

In [194]:
```
# Just run this cell

all_countries = poverty_map.column('name')
_ = widgets.interact(poverty_timeline, country=list(all_countries))
```

A Jupyter widget could not be displayed because the widget state could not be found. This could happen if the kernel storing the widget is no longer available, or if the widget state was not saved in the notebook. You may be able to create the widget by running the appropriate cells.

You're finished! Congratulations on mastering data visualization and table manipulation. Time to submit.

In [200]:
```
_ = ok.submit()
```

```
Saving notebook... Saved 'project1.ipynb'.
Submit... 100% complete
Submission successful for user: jessicarodriguez@berkeley.edu
URL: https://okpy.org/cal/data8/fa18/project1/submissions/YvXrW2 (http
s://okpy.org/cal/data8/fa18/project1/submissions/YvXrW2)
```