

Passage 24 A #1

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■ Aim of this course

Overview the history of the world population - how many people lived on the earth in the past?

Learn to describe how the world population will change using simple mathematics.

Study of human population is called "Demography". This course is also an introduction to human demography.

■ Why do we study demography?

■ The World Population now

The world population has reached 7.3 billion in 2015 and it is still increasing.

<http://www.census.gov/popclock/world>

■ The World Population in the past

Since 2000 years ago

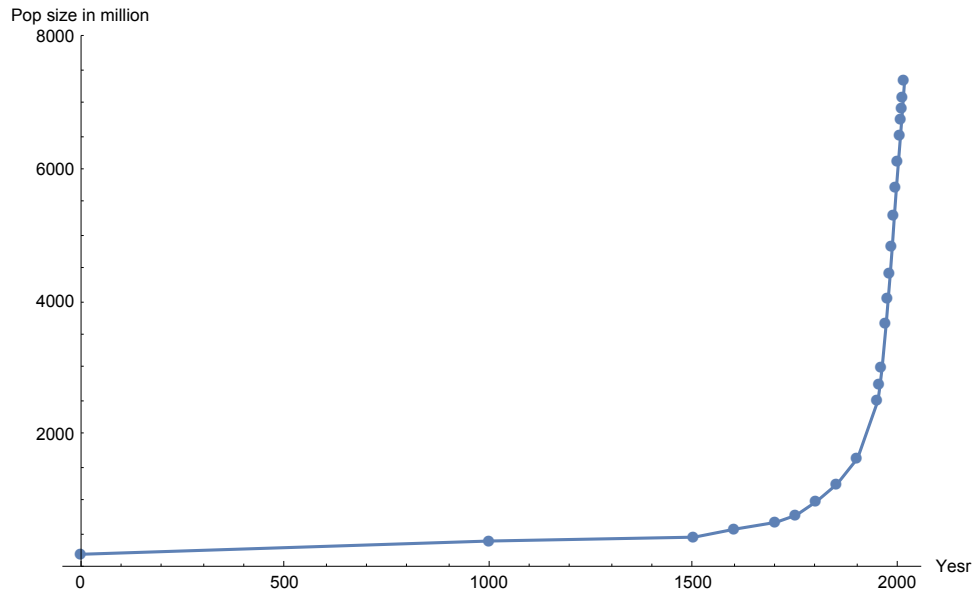
Data from Wikipedia "World population" (https://en.wikipedia.org/wiki/World_population). Population size is in million.

```
dataYearPopSize = {{0, 200}, {1000, 400}, {1500, 458}, {1600, 580},  
  {1700, 682}, {1750, 791}, {1800, 1000}, {1850, 1262}, {1900, 1650},  
  {1950, 2525}, {1955, 2758}, {1960, 3018}, {1970, 3682}, {1975, 4061},  
  {1980, 4440}, {1985, 4853}, {1990, 5310}, {1995, 5735}, {2000, 6127},  
  {2005, 6520}, {2008, 6764}, {2010, 6930}, {2012, 7097.5}, {2015, 7349}}  
  
{{0, 200}, {1000, 400}, {1500, 458}, {1600, 580}, {1700, 682},  
  {1750, 791}, {1800, 1000}, {1850, 1262}, {1900, 1650}, {1950, 2525},  
  {1955, 2758}, {1960, 3018}, {1970, 3682}, {1975, 4061}, {1980, 4440},  
  {1985, 4853}, {1990, 5310}, {1995, 5735}, {2000, 6127}, {2005, 6520},  
  {2008, 6764}, {2010, 6930}, {2012, 7097.5}, {2015, 7349}}
```

```

ListPlot[dataYearPopSize, Joined → True,
  [リストプロット [点の結合 真
PlotMarkers → Automatic, PlotRange → {0, 8000},
  [プロットマーカー 自動 [プロット範囲
AxesLabel → {"Year", "Pop size in million"}, ImageSize → 500]
  [軸のラベル [画像サイズ

```



■ The World Population in future

Since 1950 to Future projection of the world population

Data from the US Census Bureau

(http://www.census.gov/population/international/data/worldpop/table_population.php).

```

SetDirectory["/Users/takasu/home/情報科学科の仕事/講義/平成29年度/H29
  [ディレクトリの設定

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  パサージュ/Presentation/data/" ]

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/Users/takasu/home/情報科学科の仕事/講義/平成29年度/H29

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ハ°サーシ`ユ/Presentation/data

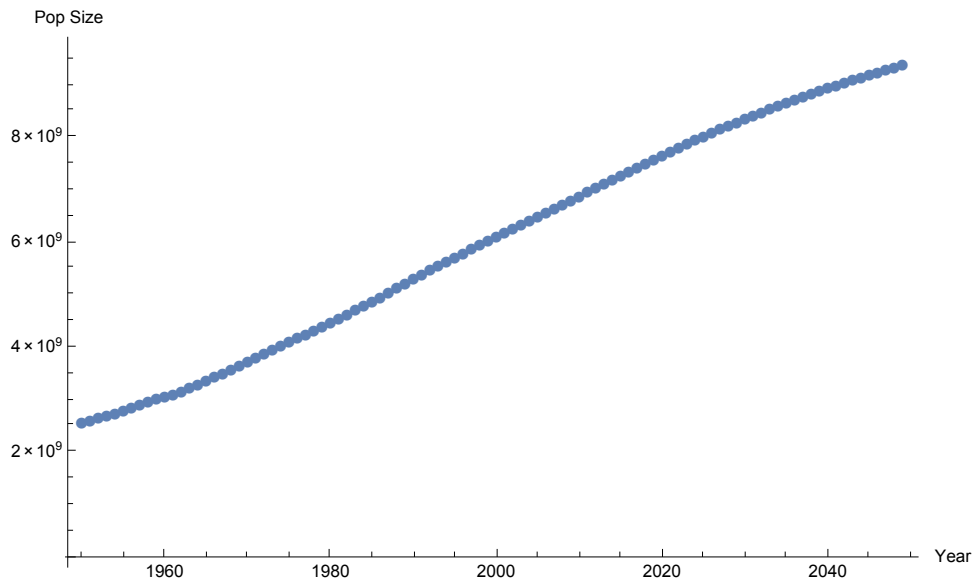
```

```

dataAll = ReadList["population_size-1950-2049.txt", {Real, Real, Real, Real}];
      [式を読みリストで返す] [実… [実… [実… [実数の頭部
{dataYear, dataPopSize, dataAGRate, dataPopChange} = Transpose[dataAll];
      [転置]
dataYearPopSize = {dataYear, dataPopSize} // Transpose
      [転置]
{{1950., 2.55763 × 109}, {1951., 2.59494 × 109},
 {1952., 2.63677 × 109}, {1953., 2.68205 × 109},
 {1954., 2.73023 × 109}, {1955., 2.7821 × 109}, {1956., 2.8353 × 109},
 {1957., 2.89135 × 109}, {1958., 2.94814 × 109}, {1959., 3.00072 × 109},
 {1960., 3.043 × 109}, {1961., 3.08397 × 109}, {1962., 3.14009 × 109},
 {1963., 3.20983 × 109}, {1964., 3.2812 × 109}, {1965., 3.35043 × 109},
 {1966., 3.42068 × 109}, {1967., 3.49033 × 109}, {1968., 3.56231 × 109},
 {1969., 3.63716 × 109}, {1970., 3.7127 × 109}, {1971., 3.79033 × 109},
 {1972., 3.86657 × 109}, {1973., 3.9421 × 109}, {1974., 4.01661 × 109},
 {1975., 4.08908 × 109}, {1976., 4.16019 × 109}, {1977., 4.23208 × 109},
 {1978., 4.30411 × 109}, {1979., 4.37901 × 109}, {1980., 4.45136 × 109},
 {1981., 4.53441 × 109}, {1982., 4.61457 × 109}, {1983., 4.69574 × 109},
 {1984., 4.77457 × 109}, {1985., 4.85646 × 109}, {1986., 4.94057 × 109},
 {1987., 5.0272 × 109}, {1988., 5.11456 × 109}, {1989., 5.20144 × 109},
 {1990., 5.28896 × 109}, {1991., 5.37159 × 109}, {1992., 5.45614 × 109},
 {1993., 5.53827 × 109}, {1994., 5.61868 × 109}, {1995., 5.6992 × 109},
 {1996., 5.77944 × 109}, {1997., 5.85797 × 109}, {1998., 5.93521 × 109},
 {1999., 6.01207 × 109}, {2000., 6.08857 × 109}, {2001., 6.16522 × 109},
 {2002., 6.24202 × 109}, {2003., 6.31859 × 109}, {2004., 6.3957 × 109},
 {2005., 6.47304 × 109}, {2006., 6.55126 × 109}, {2007., 6.62991 × 109},
 {2008., 6.70905 × 109}, {2009., 6.78821 × 109}, {2010., 6.86633 × 109},
 {2011., 6.94406 × 109}, {2012., 7.02235 × 109}, {2013., 7.10103 × 109},
 {2014., 7.17872 × 109}, {2015., 7.25649 × 109}, {2016., 7.33477 × 109},
 {2017., 7.41278 × 109}, {2018., 7.49043 × 109}, {2019., 7.5674 × 109},
 {2020., 7.6434 × 109}, {2021., 7.71826 × 109}, {2022., 7.79202 × 109},
 {2023., 7.86473 × 109}, {2024., 7.93627 × 109}, {2025., 8.00658 × 109},
 {2026., 8.07572 × 109}, {2027., 8.14373 × 109}, {2028., 8.21056 × 109},
 {2029., 8.27619 × 109}, {2030., 8.34061 × 109}, {2031., 8.40388 × 109},
 {2032., 8.46609 × 109}, {2033., 8.52725 × 109}, {2034., 8.58733 × 109},
 {2035., 8.6463 × 109}, {2036., 8.70424 × 109}, {2037., 8.76119 × 109},
 {2038., 8.81714 × 109}, {2039., 8.87207 × 109}, {2040., 8.92595 × 109},
 {2041., 8.97882 × 109}, {2042., 9.03072 × 109}, {2043., 9.08162 × 109},
 {2044., 9.13146 × 109}, {2045., 9.18023 × 109}, {2046., 9.22794 × 109},
 {2047., 9.27462 × 109}, {2048., 9.32023 × 109}, {2049., 9.36475 × 109}}

```

```
ListPlot[dataYearPopSize, Joined → True,
[リストプロット [点の結合 真
AxesLabel → {"Year", "Pop Size"}, ImageSize → 500, PlotMarkers → Automatic]
[軸のラベル [画像サイズ [プロットマーカー 自動]
```



```
dataPopSize
```

```
{2.55763 × 109, 2.59494 × 109, 2.63677 × 109, 2.68205 × 109, 2.73023 × 109, 2.7821 × 109,
2.8353 × 109, 2.89135 × 109, 2.94814 × 109, 3.00072 × 109, 3.043 × 109, 3.08397 × 109,
3.14009 × 109, 3.20983 × 109, 3.2812 × 109, 3.35043 × 109, 3.42068 × 109, 3.49033 × 109,
3.56231 × 109, 3.63716 × 109, 3.7127 × 109, 3.79033 × 109, 3.86657 × 109, 3.9421 × 109,
4.01661 × 109, 4.08908 × 109, 4.16019 × 109, 4.23208 × 109, 4.30411 × 109,
4.37901 × 109, 4.45136 × 109, 4.53441 × 109, 4.61457 × 109, 4.69574 × 109,
4.77457 × 109, 4.85646 × 109, 4.94057 × 109, 5.0272 × 109, 5.11456 × 109,
5.20144 × 109, 5.28896 × 109, 5.37159 × 109, 5.45614 × 109, 5.53827 × 109,
5.61868 × 109, 5.6992 × 109, 5.77944 × 109, 5.85797 × 109, 5.93521 × 109,
6.01207 × 109, 6.08857 × 109, 6.16522 × 109, 6.24202 × 109, 6.31859 × 109,
6.3957 × 109, 6.47304 × 109, 6.55126 × 109, 6.62991 × 109, 6.70905 × 109,
6.78821 × 109, 6.86633 × 109, 6.94406 × 109, 7.02235 × 109, 7.10103 × 109,
7.17872 × 109, 7.25649 × 109, 7.33477 × 109, 7.41278 × 109, 7.49043 × 109,
7.5674 × 109, 7.6434 × 109, 7.71826 × 109, 7.79202 × 109, 7.86473 × 109, 7.93627 × 109,
8.00658 × 109, 8.07572 × 109, 8.14373 × 109, 8.21056 × 109, 8.27619 × 109,
8.34061 × 109, 8.40388 × 109, 8.46609 × 109, 8.52725 × 109, 8.58733 × 109,
8.6463 × 109, 8.70424 × 109, 8.76119 × 109, 8.81714 × 109, 8.87207 × 109,
8.92595 × 109, 8.97882 × 109, 9.03072 × 109, 9.08162 × 109, 9.13146 × 109,
9.18023 × 109, 9.22794 × 109, 9.27462 × 109, 9.32023 × 109, 9.36475 × 109}
```

```
dataPopSizeChanged = {};
```

```
Do[
```

```
[反復指定
```

```
AppendTo[dataPopSizeChanged, dataPopSize[[i + 1]] - dataPopSize[[i]],
```

```
[追加割当て
```

```
{i, 1, Length[dataPopSize] - 1}
```

```
[長さ
```

```
]
```

dataPopSizeChanged

```
{3.73112 × 107, 4.18324 × 107, 4.52811 × 107, 4.81747 × 107, 5.18708 × 107, 5.32007 × 107,
5.605 × 107, 5.67875 × 107, 5.25793 × 107, 4.22849 × 107, 4.09654 × 107, 5.61263 × 107,
6.97347 × 107, 7.13734 × 107, 6.92245 × 107, 7.02521 × 107, 6.96558 × 107,
7.19801 × 107, 7.48452 × 107, 7.55387 × 107, 7.76292 × 107, 7.62417 × 107,
7.55278 × 107, 7.45124 × 107, 7.24744 × 107, 7.11018 × 107, 7.18996 × 107,
7.20212 × 107, 7.49082 × 107, 7.23488 × 107, 8.30474 × 107, 8.01564 × 107,
8.11702 × 107, 7.88326 × 107, 8.18933 × 107, 8.41085 × 107, 8.66293 × 107,
8.73567 × 107, 8.68829 × 107, 8.75158 × 107, 8.263 × 107, 8.45504 × 107, 8.2132 × 107,
8.04138 × 107, 8.05209 × 107, 8.02376 × 107, 7.8532 × 107, 7.72407 × 107,
7.68617 × 107, 7.64965 × 107, 7.66479 × 107, 7.67971 × 107, 7.65746 × 107,
7.71086 × 107, 7.73452 × 107, 7.82188 × 107, 7.86502 × 107, 7.9136 × 107,
7.91646 × 107, 7.8118 × 107, 7.77232 × 107, 7.82937 × 107, 7.86786 × 107, 7.7695 × 107,
7.77671 × 107, 7.82816 × 107, 7.80074 × 107, 7.76487 × 107, 7.69753 × 107,
7.59991 × 107, 7.48547 × 107, 7.37645 × 107, 7.27041 × 107, 7.15462 × 107,
7.0309 × 107, 6.91354 × 107, 6.80135 × 107, 6.68304 × 107, 6.56306 × 107,
6.44161 × 107, 6.32738 × 107, 6.22137 × 107, 6.11522 × 107, 6.00789 × 107,
5.89796 × 107, 5.79346 × 107, 5.69499 × 107, 5.59496 × 107, 5.49278 × 107,
5.38831 × 107, 5.28733 × 107, 5.19004 × 107, 5.08936 × 107, 4.98453 × 107,
4.87629 × 107, 4.77098 × 107, 4.66818 × 107, 4.56162 × 107, 4.45172 × 107}
```

dataPopSizeChangedRatio =

```
dataPopSizeChanged / Take[dataPopSize, Length[dataPopSize] - 1]
```

```
  [取り出す]           [長さ]
```

```
{0.0145882, 0.0161208, 0.0171729, 0.0179619, 0.0189987, 0.0191225, 0.0197686,
0.0196405, 0.0178348, 0.0140916, 0.0134622, 0.0181994, 0.0222078, 0.0222359,
0.0210973, 0.0209681, 0.0203632, 0.0206227, 0.0210103, 0.0207686, 0.0209091,
0.0201148, 0.0195335, 0.0189017, 0.0180437, 0.0173882, 0.0172828,
0.0170179, 0.0174039, 0.0165217, 0.0186566, 0.0176774, 0.01759, 0.0167881,
0.017152, 0.0173189, 0.0175343, 0.0173768, 0.0169874, 0.0168253, 0.0156231,
0.0157403, 0.0150532, 0.0145197, 0.0143309, 0.0140787, 0.0135882, 0.0131856,
0.0129501, 0.0127238, 0.0125888, 0.0124565, 0.0122676, 0.0122034, 0.0120933,
0.0120838, 0.0120054, 0.0119362, 0.0117997, 0.0115079, 0.0113195, 0.0112749,
0.011204, 0.0109414, 0.010833, 0.0107878, 0.0106353, 0.010475, 0.0102765,
0.010043, 0.00979338, 0.00955714, 0.00933058, 0.0090971, 0.0088592,
0.00863483, 0.00842197, 0.00820637, 0.00799344, 0.0077833, 0.00758623,
0.00740297, 0.00722319, 0.00704553, 0.00686821, 0.0067005, 0.00654278,
0.00638607, 0.00622966, 0.00607335, 0.00592355, 0.00578031, 0.00563561,
0.0054886, 0.0053401, 0.00519702, 0.00505875, 0.00491839, 0.0047764}
```

```
dataYearPopSizeChangedRatio =
```

```
{Take[dataYear, Length[dataYear] - 1], dataPopSizeChangedRatio} // Transpose
```

```

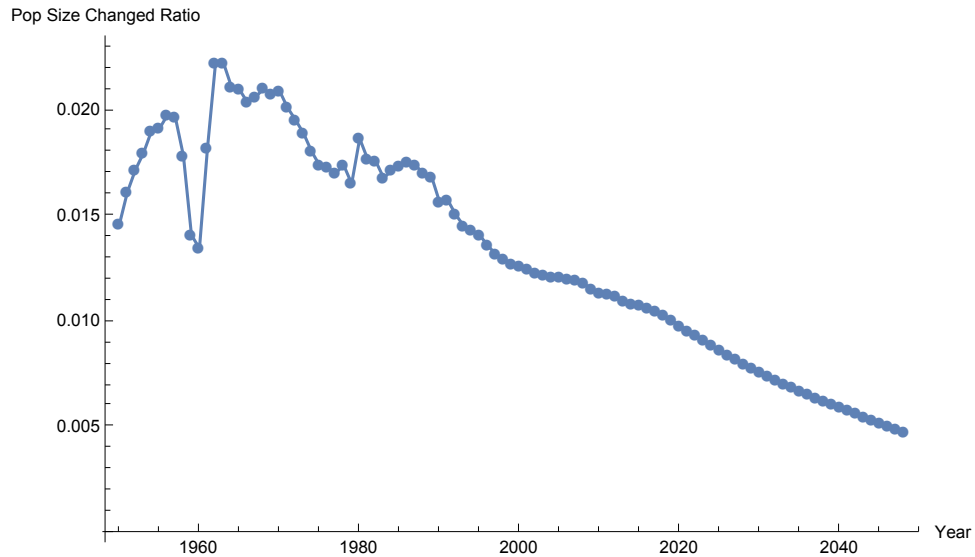
  [取り出す]      [長さ]      [転置]
  {{{1950., 0.0145882}, {1951., 0.0161208}, {1952., 0.0171729}, {1953., 0.0179619},
   {1954., 0.0189987}, {1955., 0.0191225}, {1956., 0.0197686}, {1957., 0.0196405},
   {1958., 0.0178348}, {1959., 0.0140916}, {1960., 0.0134622}, {1961., 0.0181994},
   {1962., 0.0222078}, {1963., 0.0222359}, {1964., 0.0210973}, {1965., 0.0209681},
   {1966., 0.0203632}, {1967., 0.0206227}, {1968., 0.0210103}, {1969., 0.0207686},
   {1970., 0.0209091}, {1971., 0.0201148}, {1972., 0.0195335}, {1973., 0.0189017},
   {1974., 0.0180437}, {1975., 0.0173882}, {1976., 0.0172828}, {1977., 0.0170179},
   {1978., 0.0174039}, {1979., 0.0165217}, {1980., 0.0186566}, {1981., 0.0176774},
   {1982., 0.01759}, {1983., 0.0167881}, {1984., 0.017152}, {1985., 0.0173189},
   {1986., 0.0175343}, {1987., 0.0173768}, {1988., 0.0169874}, {1989., 0.0168253},
   {1990., 0.0156231}, {1991., 0.0157403}, {1992., 0.0150532}, {1993., 0.0145197},
   {1994., 0.0143309}, {1995., 0.0140787}, {1996., 0.0135882}, {1997., 0.0131856},
   {1998., 0.0129501}, {1999., 0.0127238}, {2000., 0.0125888}, {2001., 0.0124565},
   {2002., 0.0122676}, {2003., 0.0122034}, {2004., 0.0120933}, {2005., 0.0120838},
   {2006., 0.0120054}, {2007., 0.0119362}, {2008., 0.0117997}, {2009., 0.0115079},
   {2010., 0.0113195}, {2011., 0.0112749}, {2012., 0.011204}, {2013., 0.0109414},
   {2014., 0.010833}, {2015., 0.0107878}, {2016., 0.0106353}, {2017., 0.010475},
   {2018., 0.0102765}, {2019., 0.010043}, {2020., 0.00979338}, {2021., 0.00955714},
   {2022., 0.00933058}, {2023., 0.0090971}, {2024., 0.0088592},
   {2025., 0.00863483}, {2026., 0.00842197}, {2027., 0.00820637},
   {2028., 0.00799344}, {2029., 0.0077833}, {2030., 0.00758623},
   {2031., 0.00740297}, {2032., 0.00722319}, {2033., 0.00704553},
   {2034., 0.00686821}, {2035., 0.0067005}, {2036., 0.00654278},
   {2037., 0.00638607}, {2038., 0.00622966}, {2039., 0.00607335},
   {2040., 0.00592355}, {2041., 0.00578031}, {2042., 0.00563561},
   {2043., 0.0054886}, {2044., 0.0053401}, {2045., 0.00519702},
   {2046., 0.00505875}, {2047., 0.00491839}, {2048., 0.0047764}}

```

```

ListPlot[dataYearPopSizeChangedRatio, Joined → True,
  [リストプロット [点の結合 [真
  AxesLabel → {"Year", "Pop Size Changed Ratio"},
  [軸のラベル
  ImageSize → 500, PlotMarkers → Automatic]
  [画像サイズ [プロットマーカー [自動

```



■ Questions

How did the world population change in the past?
 What is annual growth rate (%)?
 How will it change in future? How can we predict it?

■ Reference

How many people can the earth support? J E Cohen. 1995. W W Norton & Company, New York.
 Population: An introduction to concepts and issues 8th edition. John R Weeks. 2002. Wadsworth
 Groups.
 Lecture by Prof. J E Cohen at the Floating University: <http://www.floatinguniversity.com/lectures-cohen>