

# 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.  
This course is also an introduction to human demography.

## ■ What is demography?

Demography is a science of population. A population consists of a certain number of individuals of the same biological species (e.g., Homo sapiens as human being, biological species, etc.). Population size, or the number of individuals, changes with time by birth, death, and immigration in and emigration out. Demography focuses on social, economical, cultural, and biological aspects of populations.

## ■ Why do we study demography?

Consider why?

## ■ The World Population now

The world population has reached 7.3 billion in 2015 and it is still increasing. Now in 2018, it is over 7.4 billion.  
<http://www.census.gov/popclock/world>

## ■ The World Population in the past

### Since 2000 years ago

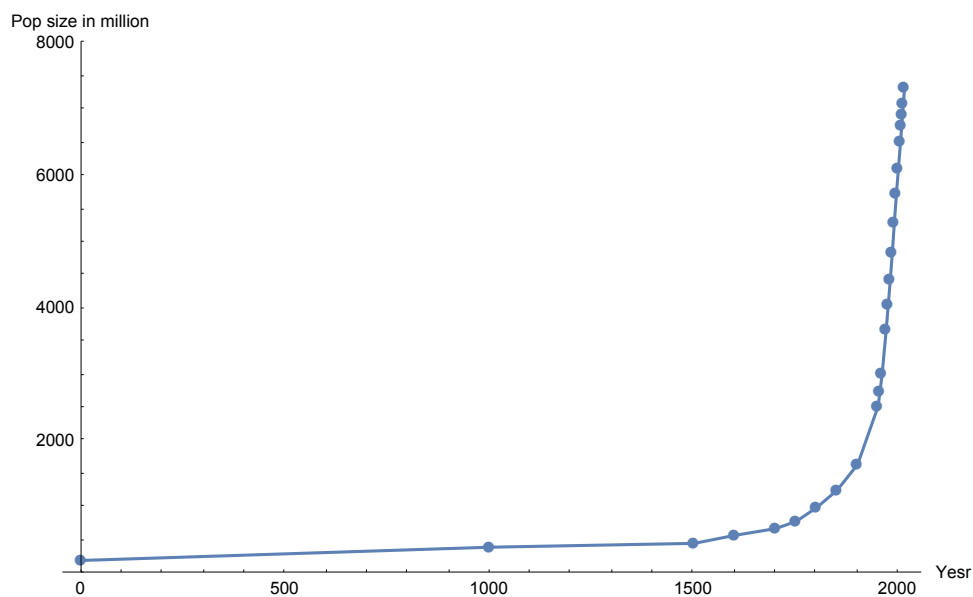
Data from Wikipedia "World population" ([https://en.wikipedia.org/wiki/World\\_population](https://en.wikipedia.org/wiki/World_population)). Population size is in million.

```

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,
  PlotMarkers -> Automatic, PlotRange -> {0, 8000},
  AxesLabel -> {"Year", "Pop size in million"}, ImageSize -> 500]

```



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

```
SetDirectory["/Users/takasu/home/化学生物環境学科の仕事/講義/平成30年度/H30
  パサージュ/Presentation/data/"]
```

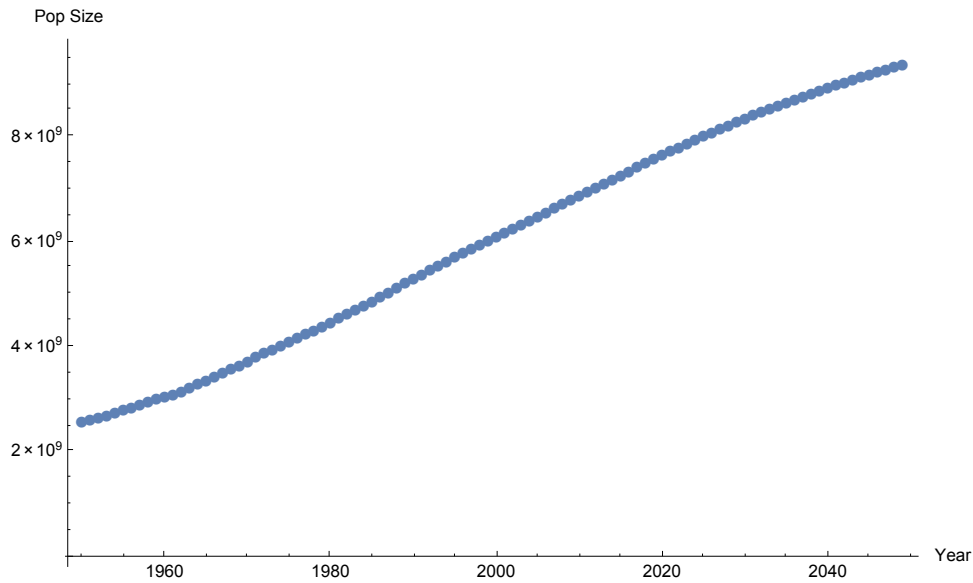
```
/Users/takasu/home/化学生物環境学科の仕事/講義/平成30年度/H30
  パサージュ/Presentation/data
```

```

dataAll = ReadList["population_size-1950-2049.txt", {Real, Real, Real, Real}];
{dataYear, dataPopSize, dataAGRate, dataPopChange} = Transpose[dataAll];
dataYearPopSize = {dataYear, dataPopSize} // Transpose
{ {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,
  AxesLabel → {"Year", "Pop Size"}, ImageSize → 500, PlotMarkers → Automatic]
```



```
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[
```

```
  AppendTo[dataPopSizeChanged, dataPopSize[[i + 1]] - dataPopSize[[i]],
    {i, 1, Length[dataPopSize] - 1}
```

```
]
```

**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]
```

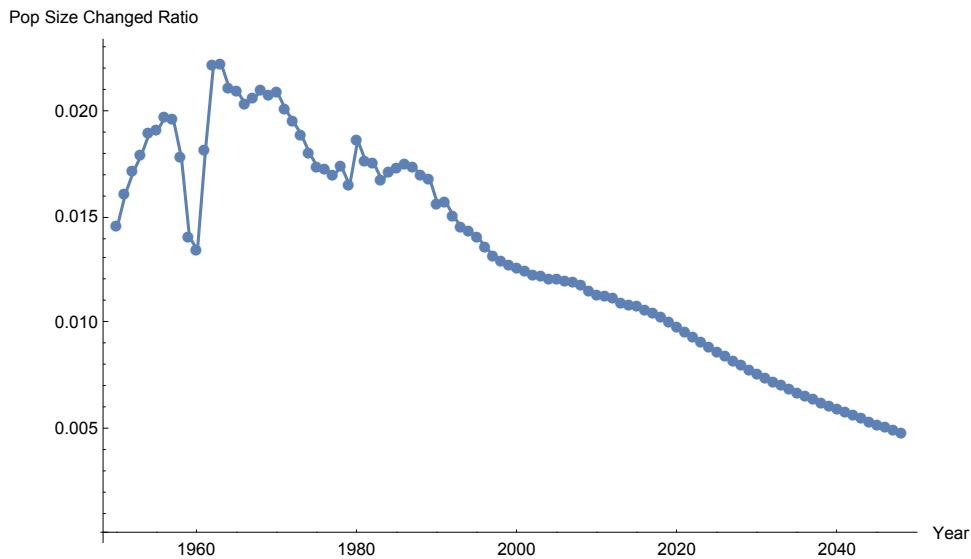
```
{0.0145882, 0.0161208, 0.0171729, 0.0179619, 0.0189987, 0.0191225, 0.0197686,
0.0196405, 0.0178348, 0.0140916, 0.0134622, 0.0181994, 0.0222078, 0.0222359,
0.0210973, 0.0209681, 0.0203632, 0.0206227, 0.0210103, 0.0207686, 0.0209091,
0.0201148, 0.0195335, 0.0189017, 0.0180437, 0.0173882, 0.0172828,
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
  {{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,
    AxesLabel → {"Year", "Pop Size Changed Ratio"},
    ImageSize → 500, PlotMarkers → Automatic]
  
```



## ■ 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>

Youtube: [https://www.youtube.com/watch?v=2vr44C\\_G0-o](https://www.youtube.com/watch?v=2vr44C_G0-o)