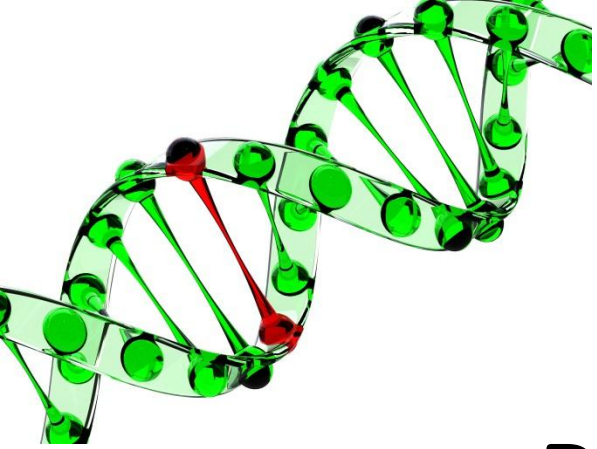
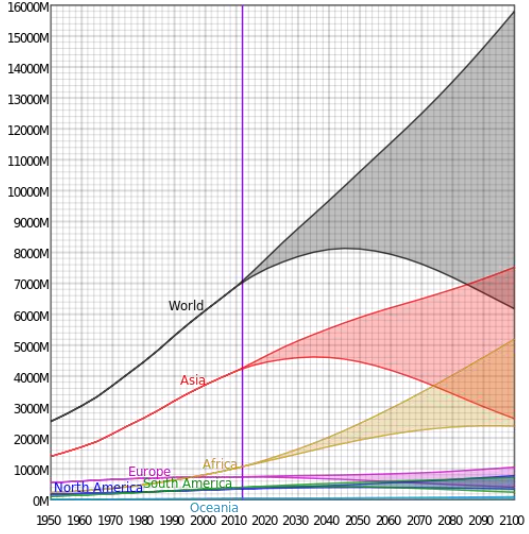


Population Growth



Natural selection is noncontroversial and inevitable

- Three conditions:
  - Phenotypic variation (V_P is not zero)
  - Inheritance of the variation (heritability is not zero)
  - Variation affects survival or reproduction

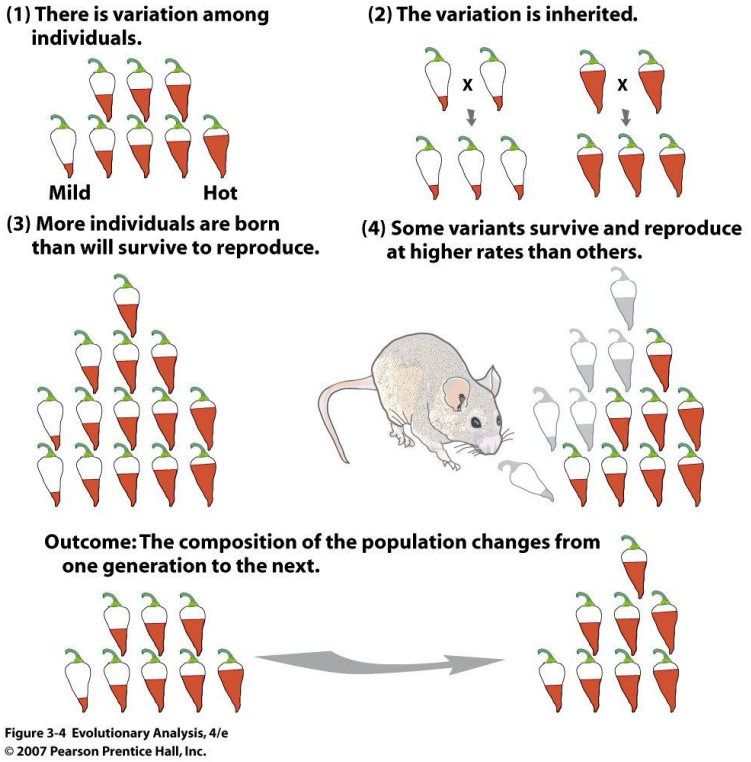
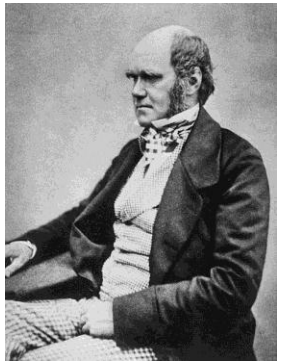


Figure 3-4 Evolutionary Analysis, 4/e

Original concept of natural selection tied to population growth

- **Malthus** (economist)**-** populations kept from growing by limited food/ resources
- **Darwin-** this limitation produces struggle wherein those better able to reproduce will spread

- ... but how do natural populations grow (or not)?



Capacity to grow is great

- To maintain a constant population, each pair of organisms should produce **2** surviving offspring

- If conditions favorable, how many offspring ***can*** most organisms produce?
  - Think seeds/ pollen
  - Think insect larvae
  - Think cane toad eggs

Capacity to grow is great

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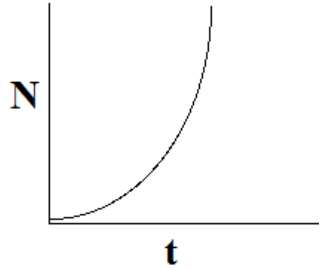
Rate of increase

- Populations can be modeled with a “stable” rate of increase
  - Birth rate (# births per thousand per year)
  - Death rate (# deaths per thousand per year)
  - Birth rate – Death rate = rate of increase (**r**)
  - USA example: b= 14/1000, d= 6/1000, r= 0.008
    - Population grows naturally by 0.8% per year

- If birth rate > death rate, population grows

Effect on population size



N = population size, t = time in years

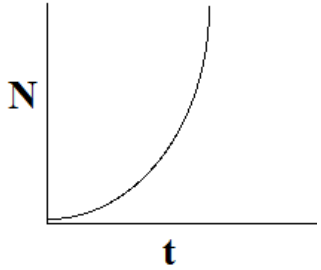
dN/dt = r N : standard rate of population growth

- Algebraic solution:

$N_t = N_0 e^{rt}$, where N_t is the population at time = t and N_0 is the population at time = 0

What is the population doubling time (the time it takes to reach double the current population size)?

Effect on population size



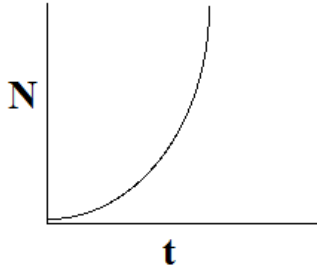
$N_t = N_0 e^{rt}$, where N_t is the population at time t.

N_0 is the population at time 0.

Double = $2N_0$, solve for t

US N_0=310 million, r=0.008

Effect on population size



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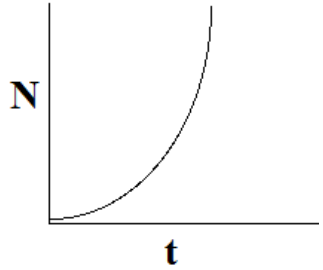
Double = $2N_0$, solve for t

$2 N_0 = N_0 e^{rt}$

$2 = e^{rt}$

US N_0=310 million, r=0.008

Effect on population size



$N_t = N_0 e^{rt}$, where N_t is the population at time t.

N_0 is the population at time 0.

Double = $2N_0$, solve for t

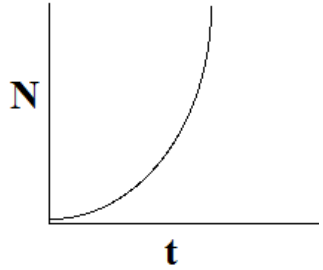
$2 N_0 = N_0 e^{rt}$

$2 = e^{rt}$, Take natural log (ln) of both sides

$\ln(2) = \ln(e^{rt})$

US N_0=310 million, r=0.008

Effect on population size



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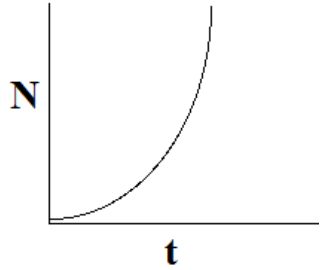
$\ln(2) = \ln(e^{rt})$

$0.693 = rt$

US N_0=310 million, r=0.008

Effect on population size



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$2 = e^{rt}$, Take natural log (ln) of both sides

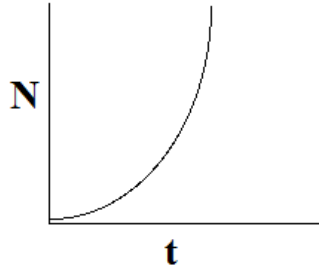
$\ln(2) = \ln(e^{rt})$

$0.693 = rt$

Doubling time = $t = 0.693 / r$

US N_0=310 million, r=0.008

Effect on population size



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Double = $2N_0$, solve for t

$2 N_0 = N_0 e^{rt}$

$2 = e^{rt}$, Take natural log (ln) of both sides

$\ln(2) = \ln(e^{rt})$

$0.693 = rt$

Doubling time = $t = 0.693 / r$

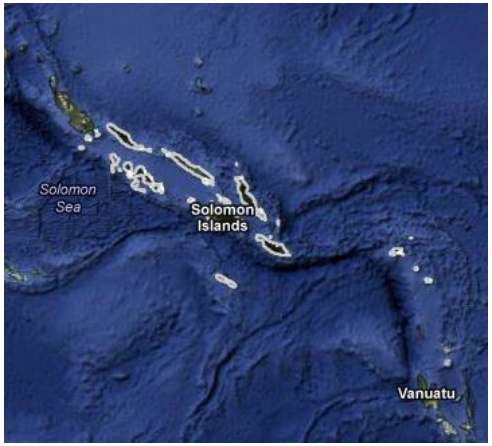
For USA, $t = 0.693 / 0.008 = 86.6$ years

Time to 620 million!!!

US N_0=310 million, r=0.008

Solomon Islands

- Birth rate= 35/1000, Death rate= 5/1000
  Population size (today)= 500,000



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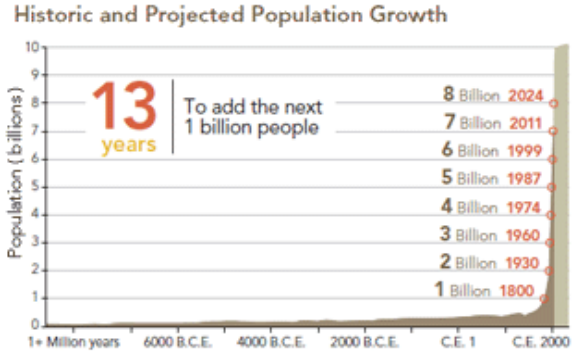
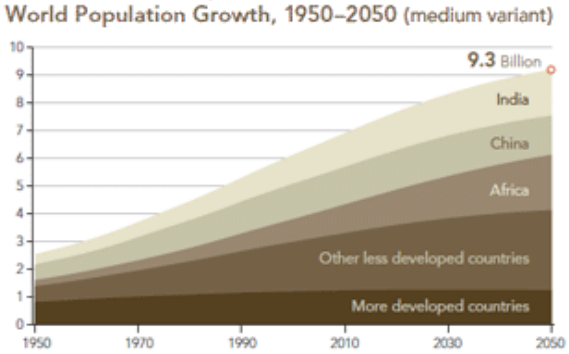
Population growth rate and projections





SOURCES: CARL HAUB, POPULATION REFERENCE BUREAU (PRB), 2010; U.N. POPULATION DIVISION (UNPD), 2011

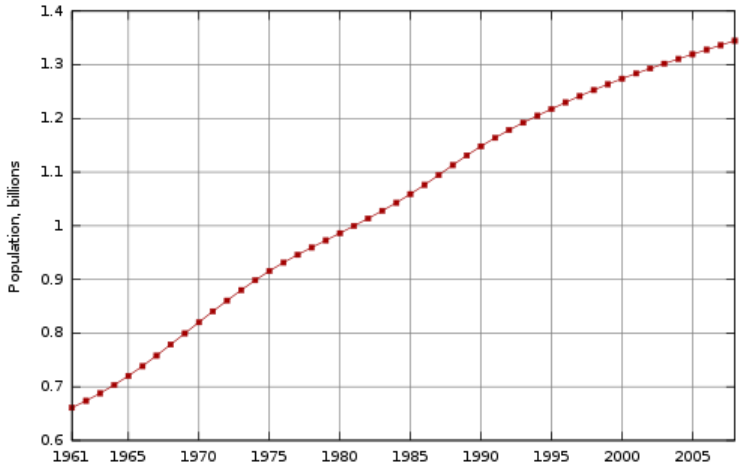
SOURCE: UNPD, 2011

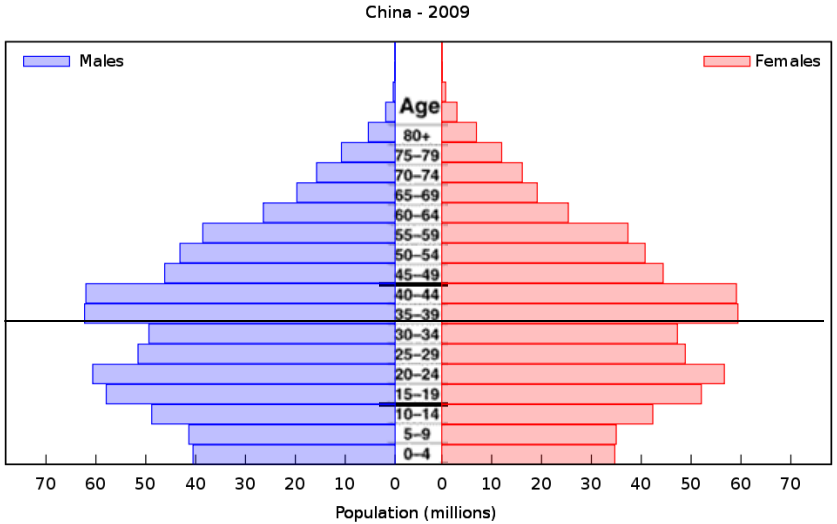
SOURCE: UNPD, 2011

Tipping point. The period of most rapid population growth is behind us. Since its peak in 1965–70, the growth rate has declined, falling roughly by half in 40 years as women have had fewer children.

Attempts to address overpopulation:

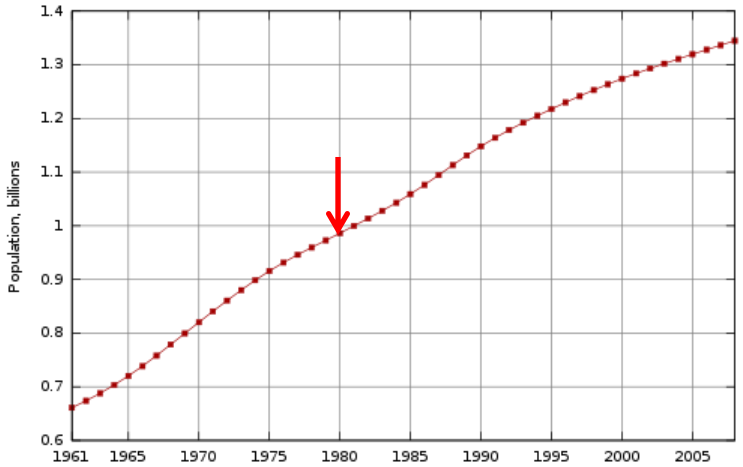
- China's "One-Child" policy (see pictures below)

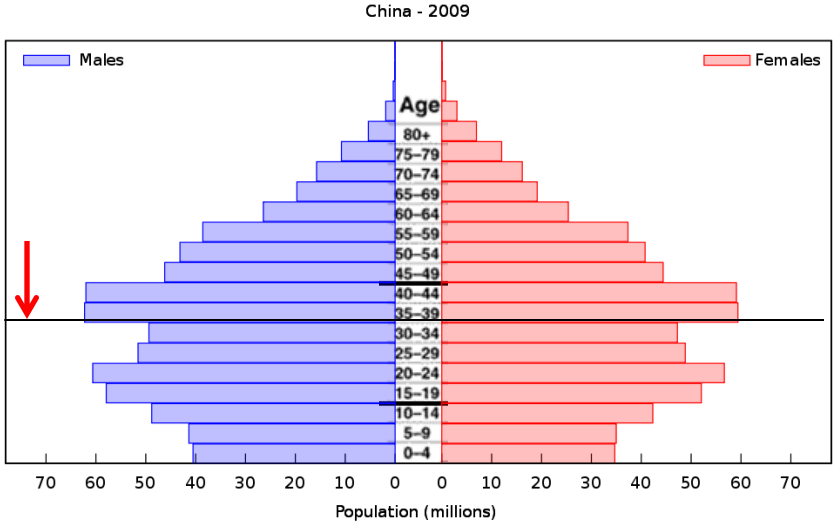




Attempts to address overpopulation:

- China's "One-Child" policy (see pictures below)

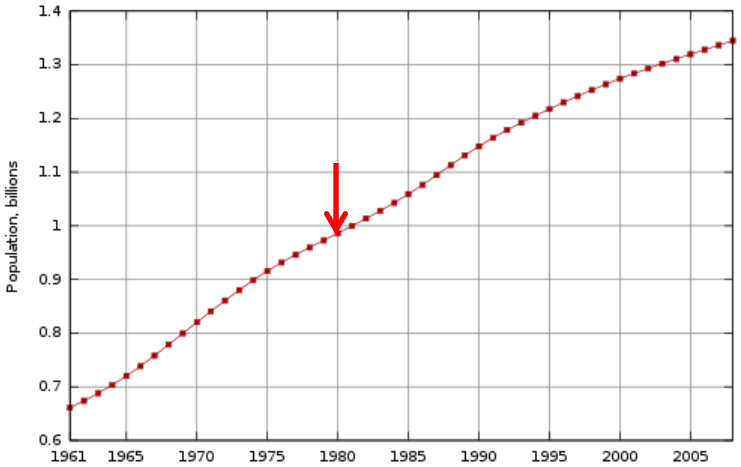




Why???

Attempts to address overpopulation:

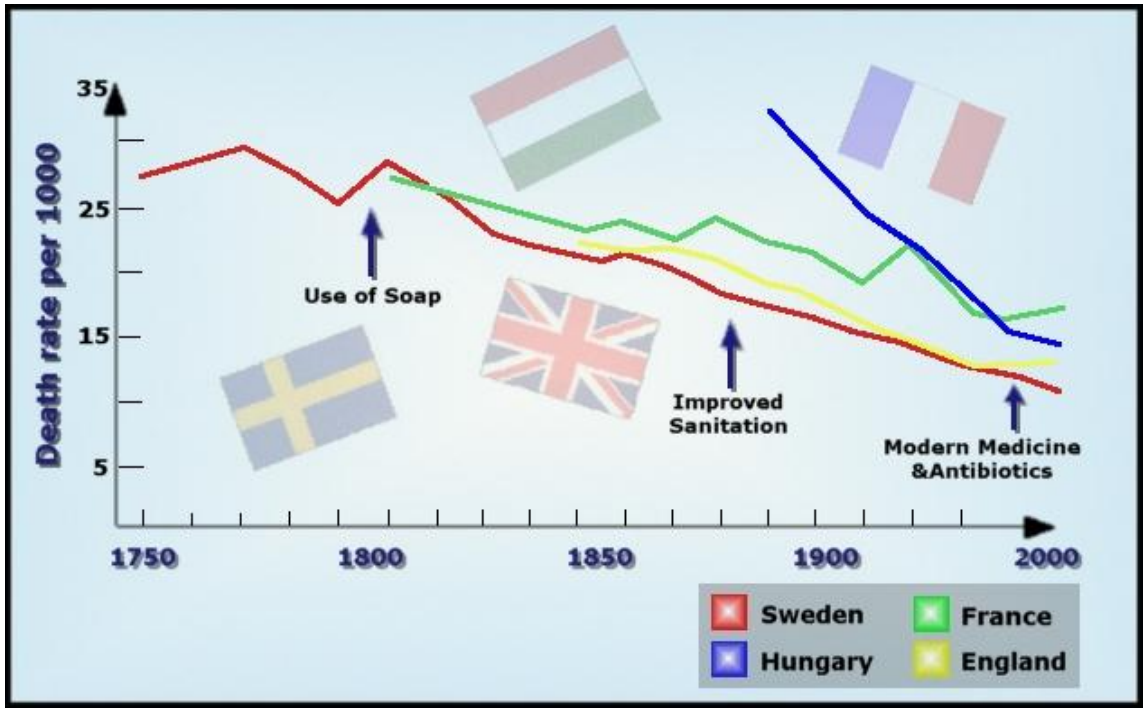
- China's "One-Child" policy (see pictures below)



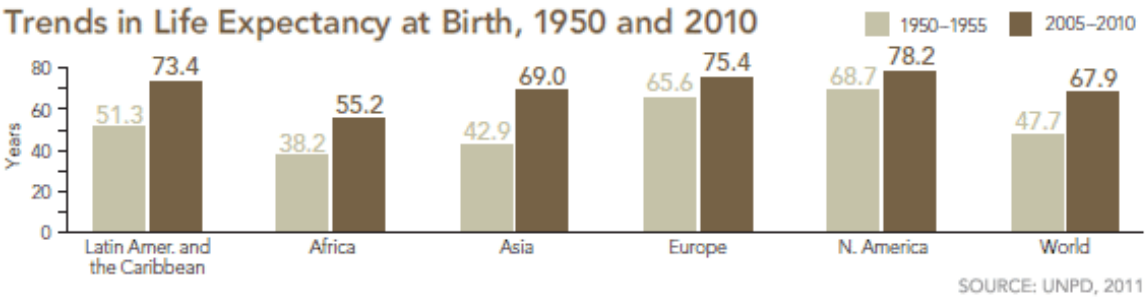
- Causes of population growth?
  - High birth rate
  - Low death rate

- Cut birth rate and still see growth
  - Death rate decreased faster than birth rate decreased

Declining mortality (death) rates...

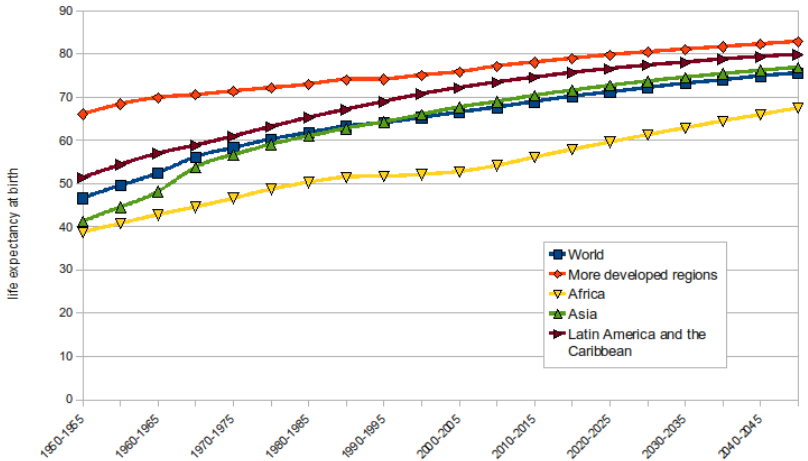


Life Expectancies, 1950 vs 2010



Life Expectancy at Birth by Region, 1950-2050.

Source: UN World Population Prospects, 2008.



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