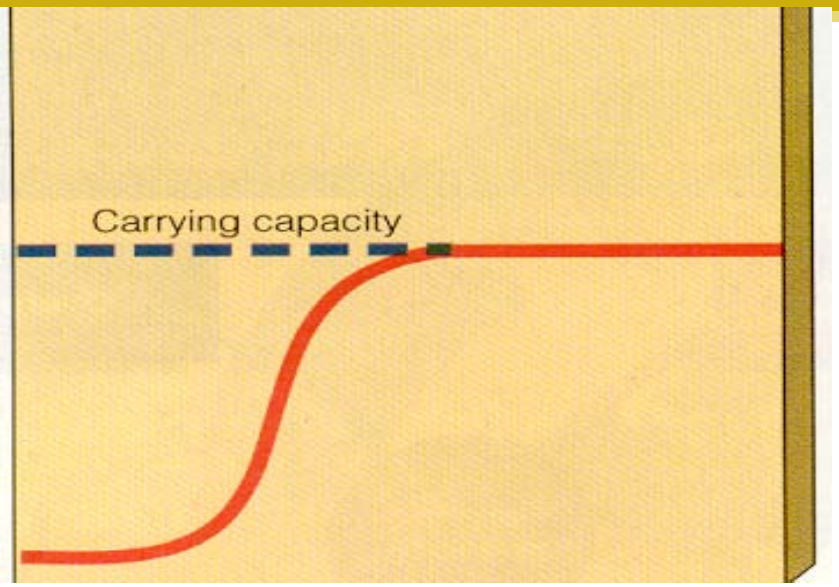
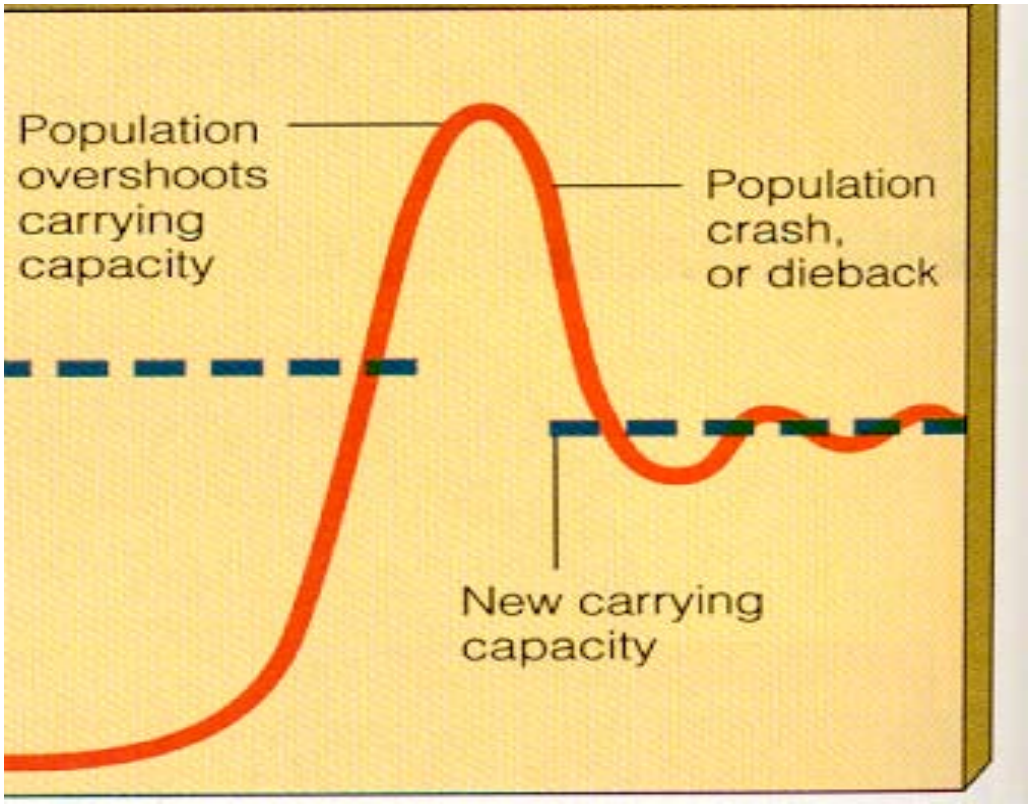
AP Environmental Science

Populations

Population Biology Concepts

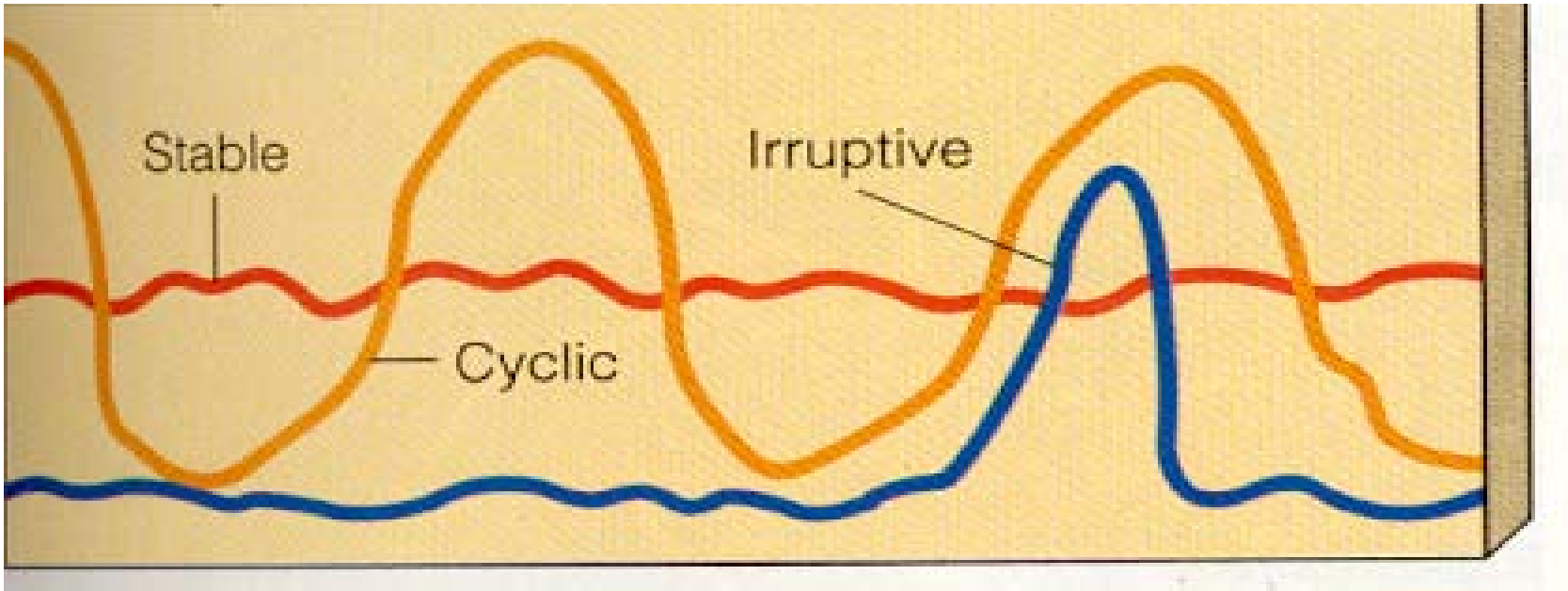
Population ecology, carrying capacity, reproductive strategies, survivorship curves

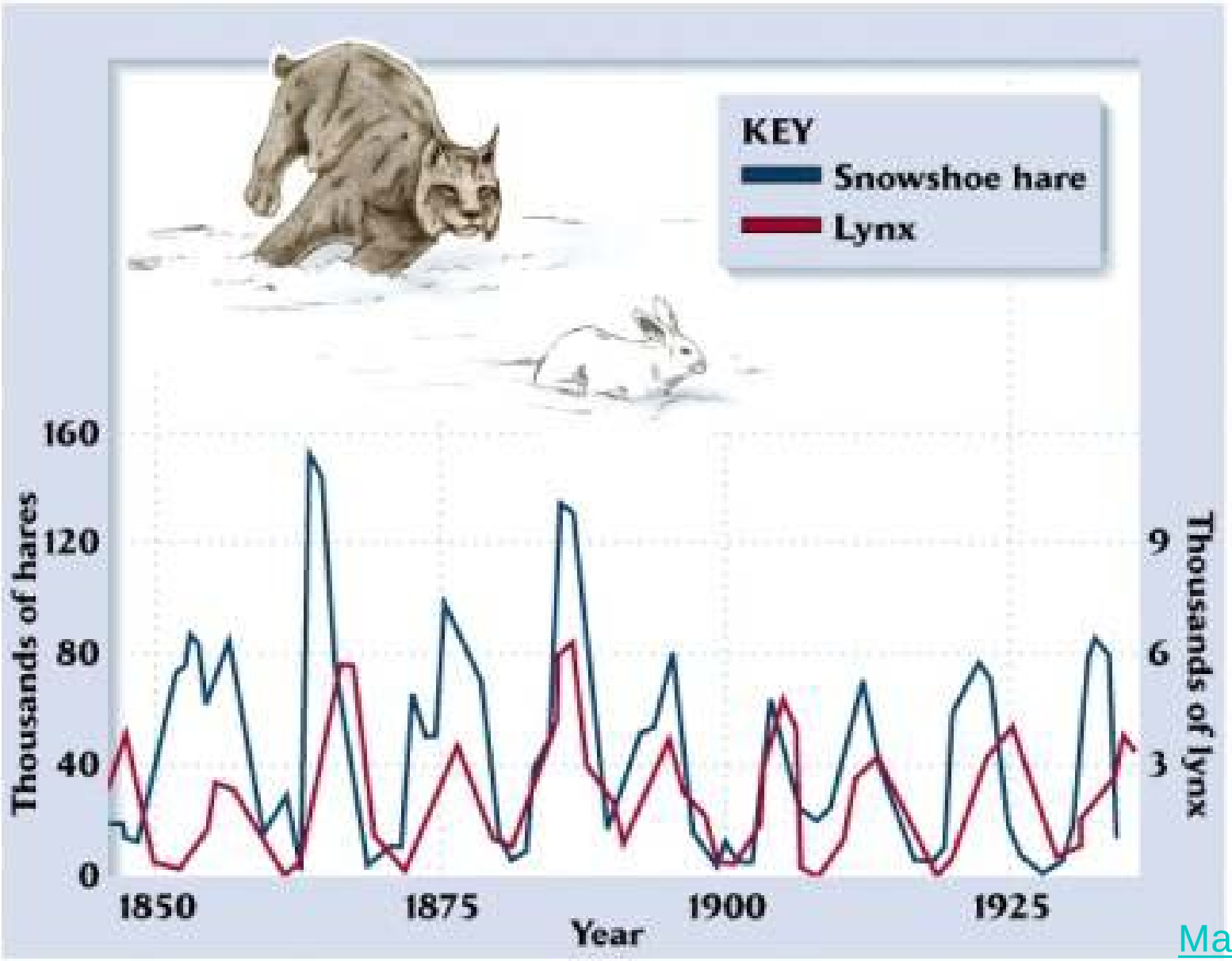

Carrying capacity


Population overshoots carrying capacity
Population crash, or dieback
New carrying capacity

Population cycles in nature

- **relatively stable** - slight fluctuation above and below carrying capacity, ex:tropical rain forest
- **erupt -** high peak, crash - raccoons
- **cyclic** - “boom” and “bust”





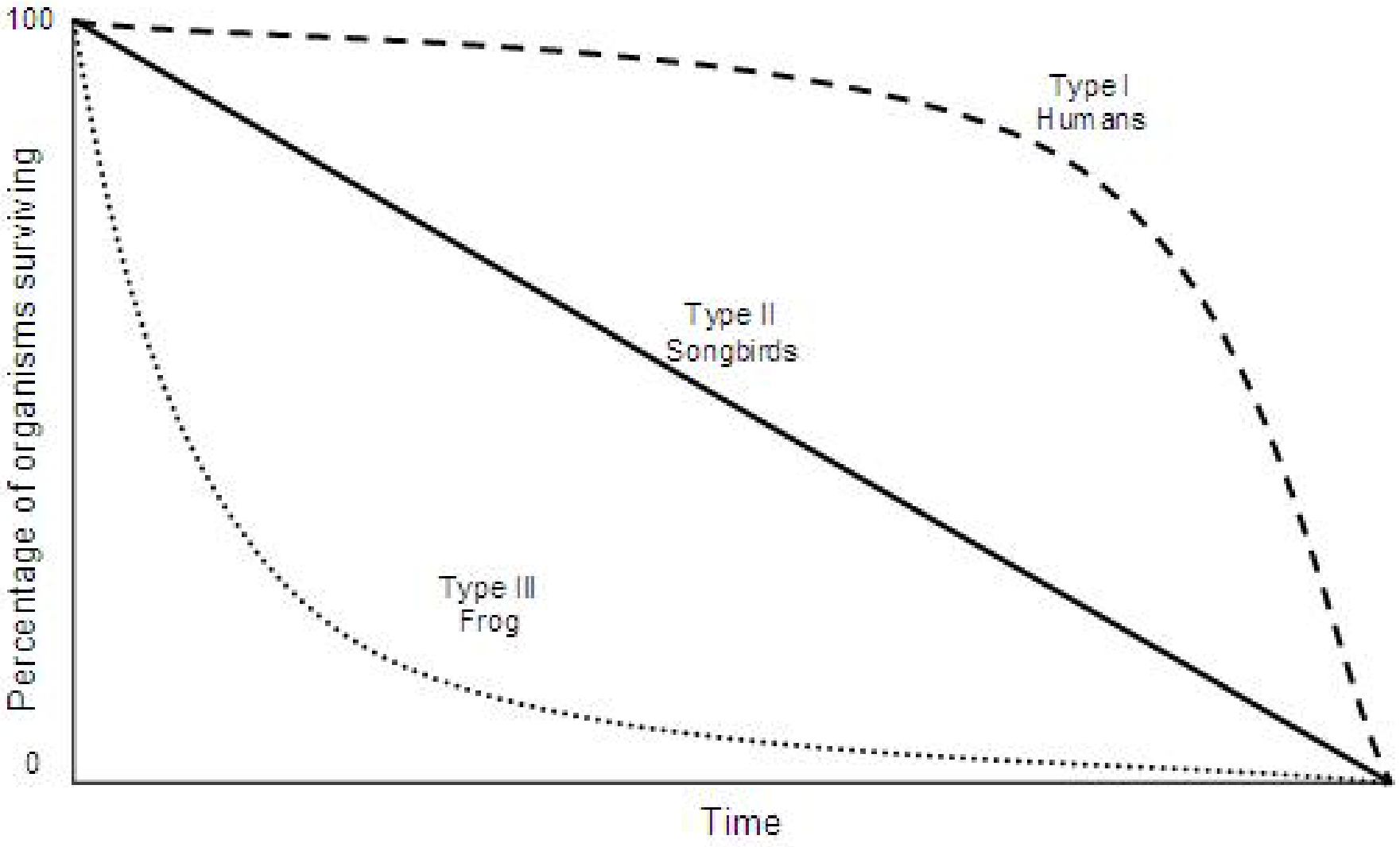
[Marty Stouffer's Great Escapes Video]

Population Basics

- Size/ Density/ Dispersion
- Growth Rate= Birth Rate- Death Rate
  - GR= (Birth rate+ immigration) – (death rate + emigration)
- Carrying Capacity (K)
- Biotic Potential / Environmental Resistance(Abiotic & biotic)
- r-strategist and K-strategist

Survivorship Curves

- A graph showing the number or proportion of individuals surviving at each age for a given species or group
- Three Generalized Types (I, II, III)
  - Type I – high survival rate in early and middle stages and rapid decline in later life
    - Ex Humans
  - Type II – Roughly constant rate of survival/ mortality regardless of age
    - Ex Birds
  - Type III - high mortality rate early in life, lower death rates in middle and late stages
    - Ex r-Strategists


100
0
Percentage of organisms surviving
Type I
Humans
Type II
Songbirds
Type III
Frog
Time

Human Population Dynamics

Historical population sizes, distribution, fertility rates, growth rates, doubling times, demographic transitions, age-structure diagrams

How Has the Human Population Grown Historically

A. **Early Hunter Gatherers**
   1. Nomadic, With a Strong Sense of the Earth
   2. Practiced Intentional Birth Control

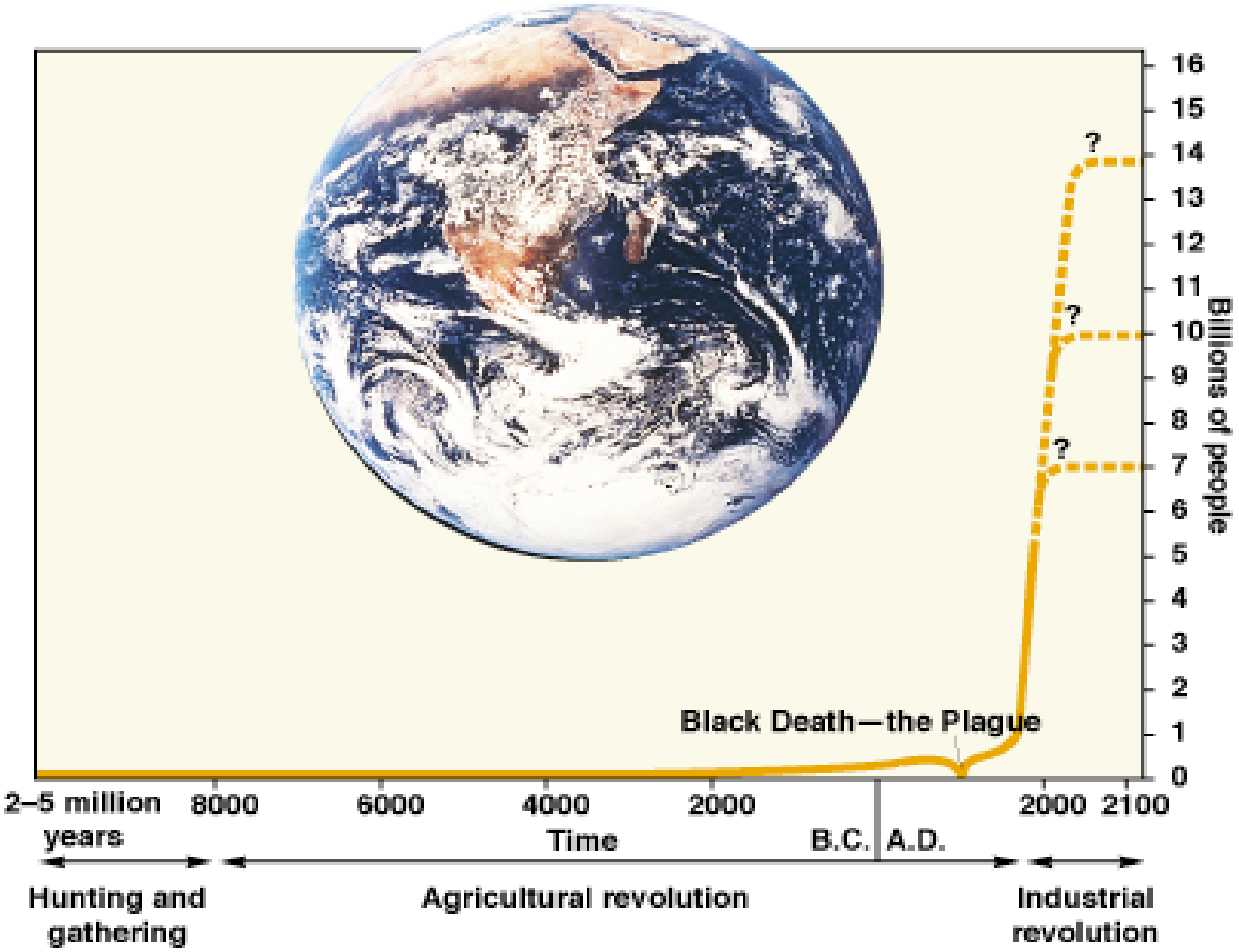
B. **Rise of Agriculture**
   1. Necessary for Survival
      a. Animals became extinct via predation and altered habitat
      b. Humans began to cultivate own food

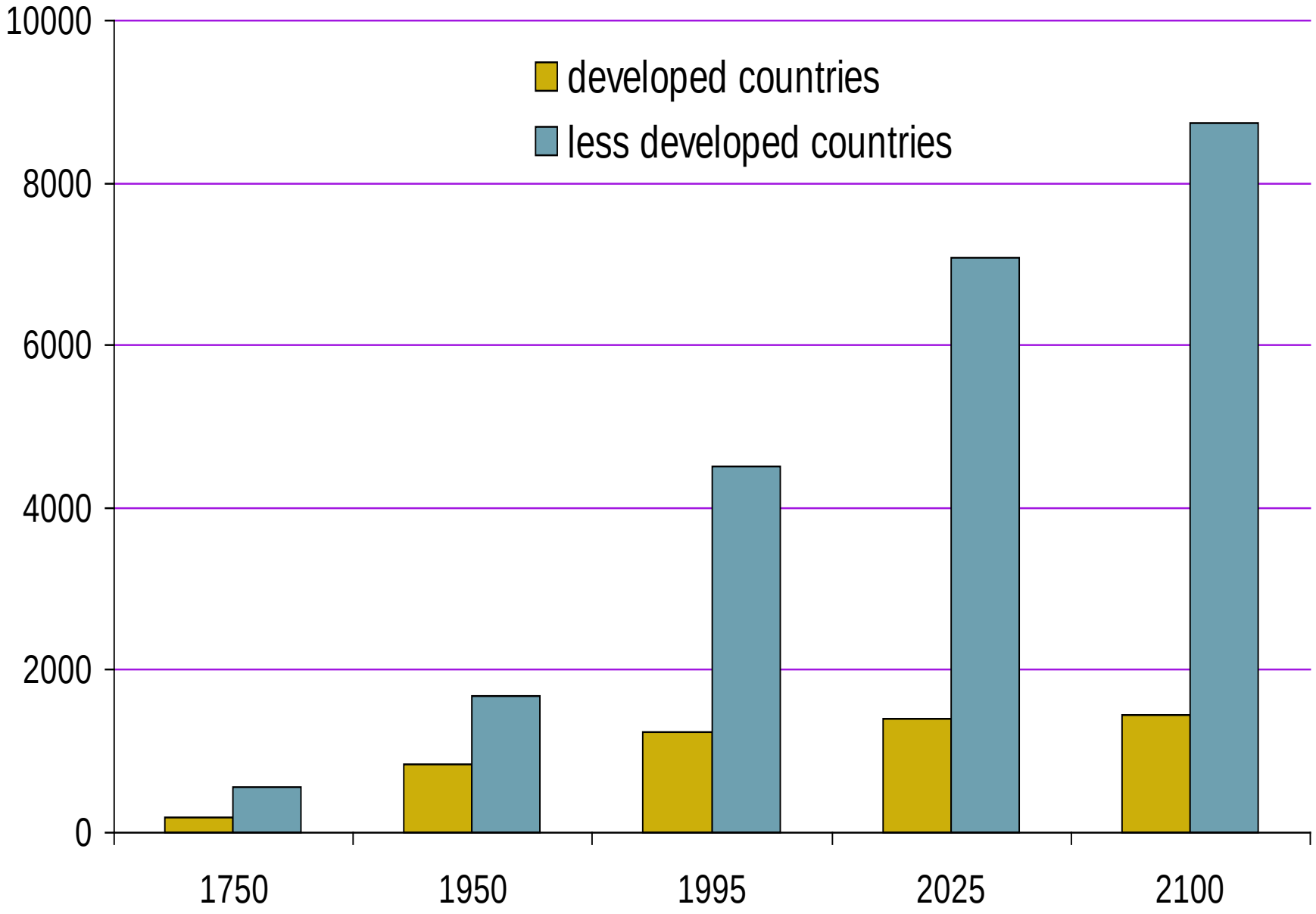
C. Agriculture Gives Rise to Cities

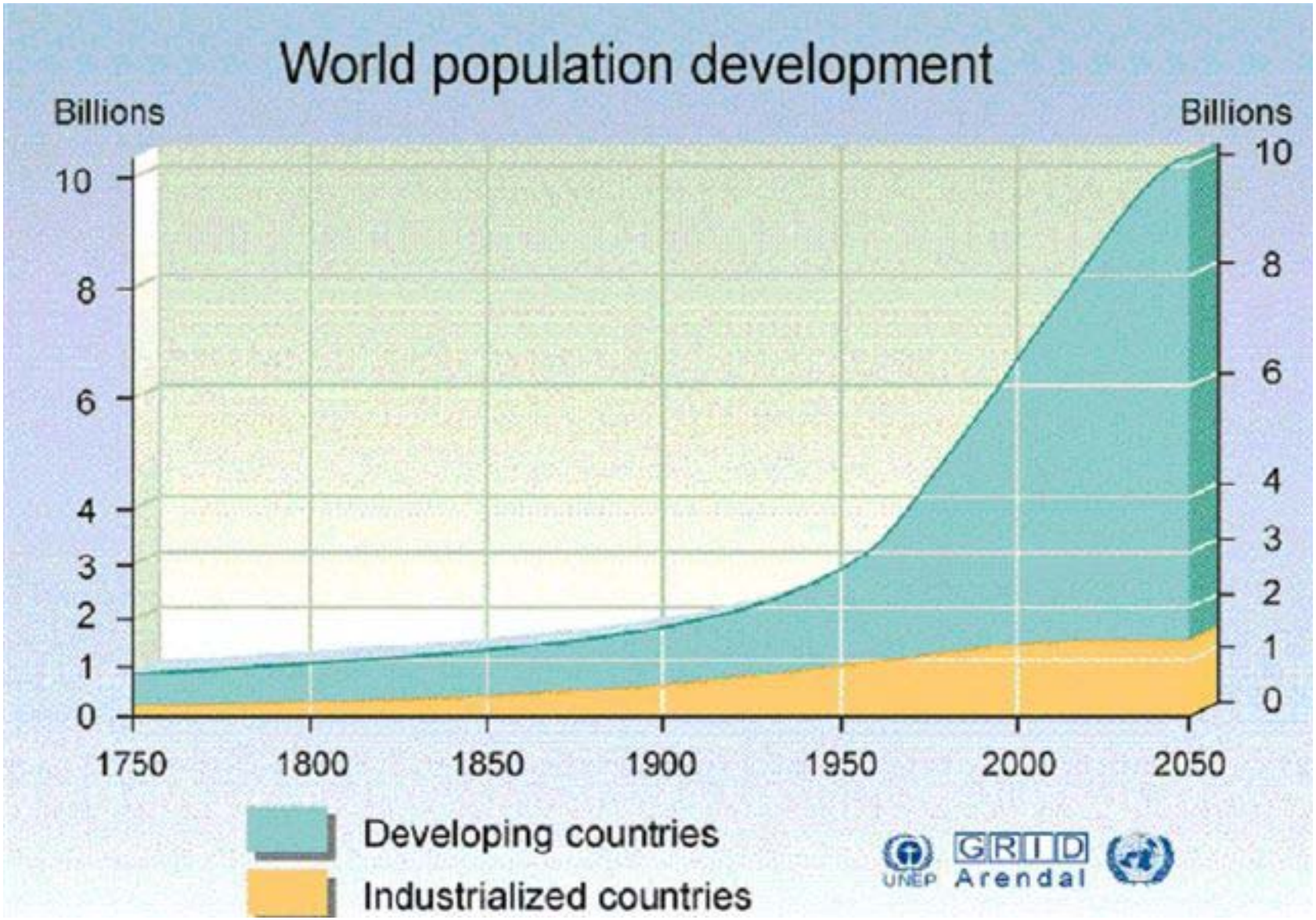
1. Food Produced in Country, Consumed in City
   a. Food wastes are no longer returned to soil
   b. Soil becomes less productive
2. Waste of Populations Concentrated in Cities
3. Population Control in Medieval Societies
   a. Infanticide
   b. Plagues

D. Industrialization

1. View of Children During Early Phases of Industrial Growth
   a. Valued as cheap source of income and cheap labor
   b. Exponential growth of populations
2. By 1900s, Birth Rate in Industrialized World Dropped
   a. Rise in standards of living
   b. Safe and inexpensive means of birth control introduced
   c. Increase in the cost of child rearing


16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Billions of people
?
?
?
Black Death—the Plague
2–5 million years
8000
6000
4000
2000
B.C.
A.D.
2000
2100
Time
Hunting and gathering
Agricultural revolution
Industrial revolution


10000
8000
6000
4000
2000
0
developed countries
less developed countries
1750
1950
1995
2025
2100


World population development
Billions
Billions
10
8
6
4
3
2
1
0
10
8
6
4
3
2
1
0
1750
1800
1850
1900
1950
2000
2050
Developing countries
Industrialized countries
UNEP
GRID
Arendal

Current World Population

- Population Clock Vital Events (per time unit)

Global population was 6,807,825,208
On March 11, 2010 at 8:00 am

- The global population grows by:
  - Nearly **2.3** persons per seconds
  - Nearly **8,343** persons per hour
  - Over **200,234** persons per day
  - Over **73 million** persons per year

How Much is a Billion?

- 1,000 seconds = 16.7 minutes
- 1 million-s = 16,677 min = 11.6 days
- 1 billion-s = 11,574 days = 31.7 years

- 1,000 pennies = ~ 88 ounces = 5.5 pounds
- 1 million pennies = 5,500 pounds (~1-Suburban)
- 1 billion pennies = 2,750 tons (~2 Space Shuttles)

Human Population Dynamics

- There are just three sources of change in population size —

1. fertility
2. mortality
   A. "natural decrease" refers to population decline resulting from more deaths than births
3. migration
   - Net migration is the number of immigrants minus emigrants

Rates of Global Pop. Change

use: International Data Base http://www.census.gov/ipc/www/idbnew.html,
then Online Demographic Aggregation

- **CBR** (crude birth rate) = # births / 1000 population

  1990: 24 now: **19.95**

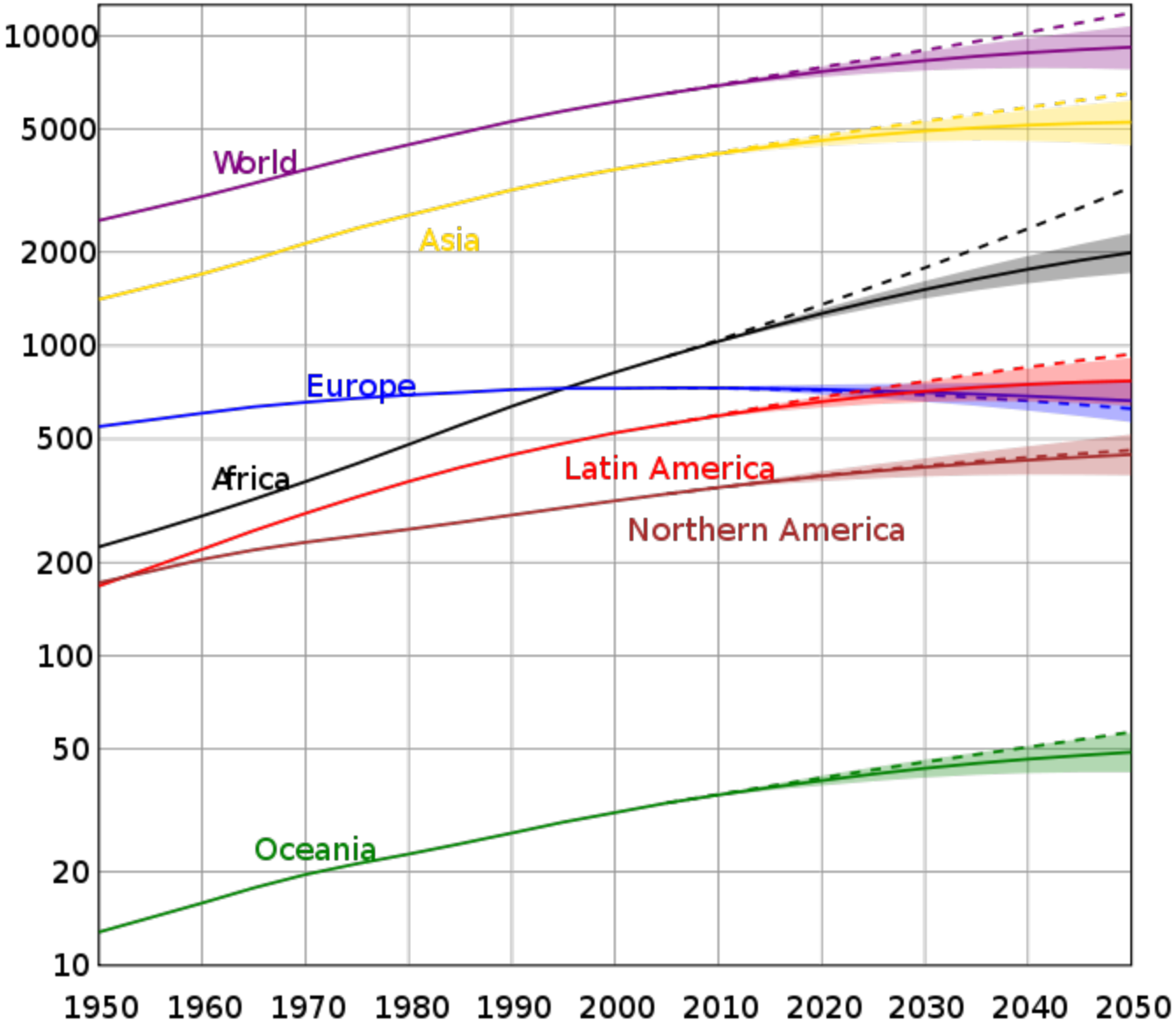
- **CDR** (crude death rate) = # deaths / 1000 population

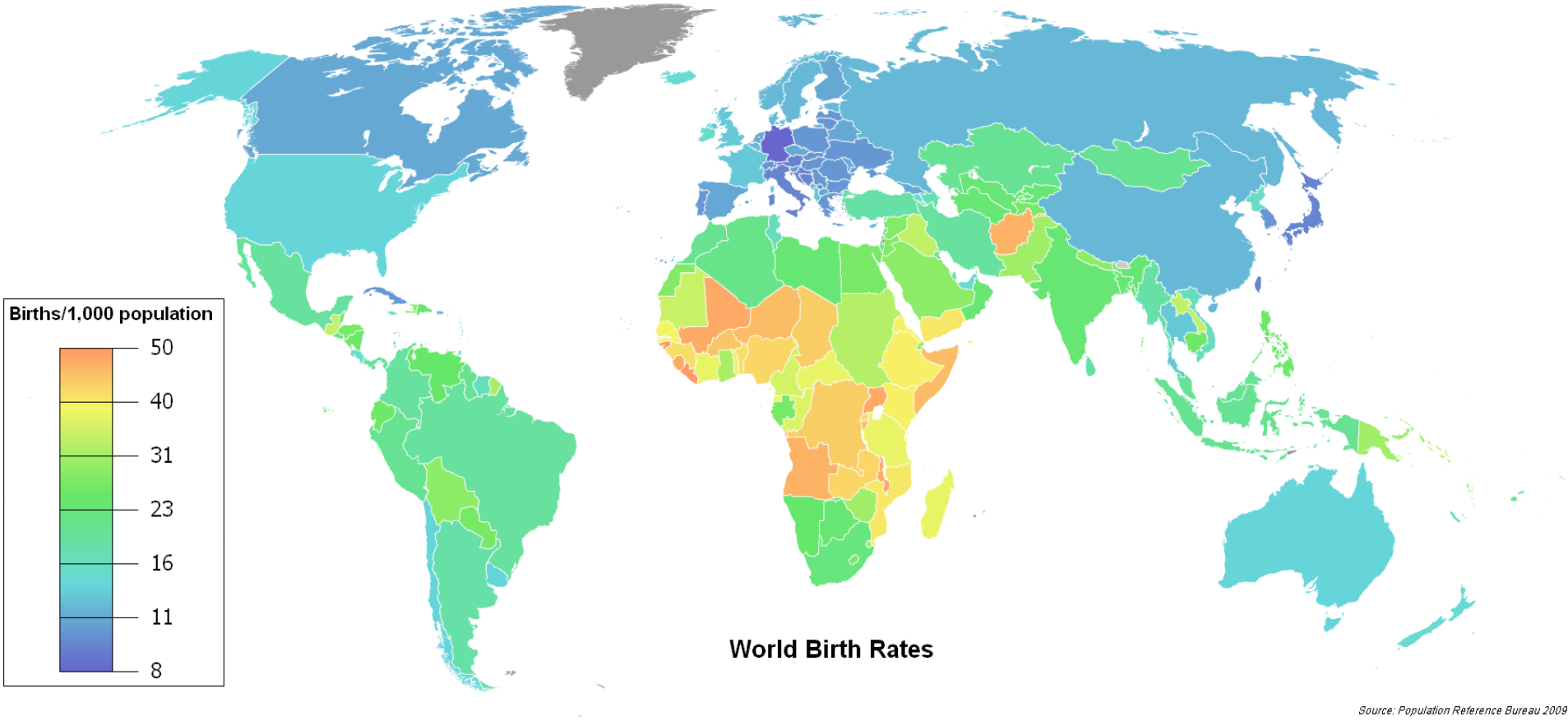
  1990: 9 now: **8.24**

- **Growth Rate** = (b + i) – (d + e)

  1990: 1.5% now: **1.17%**

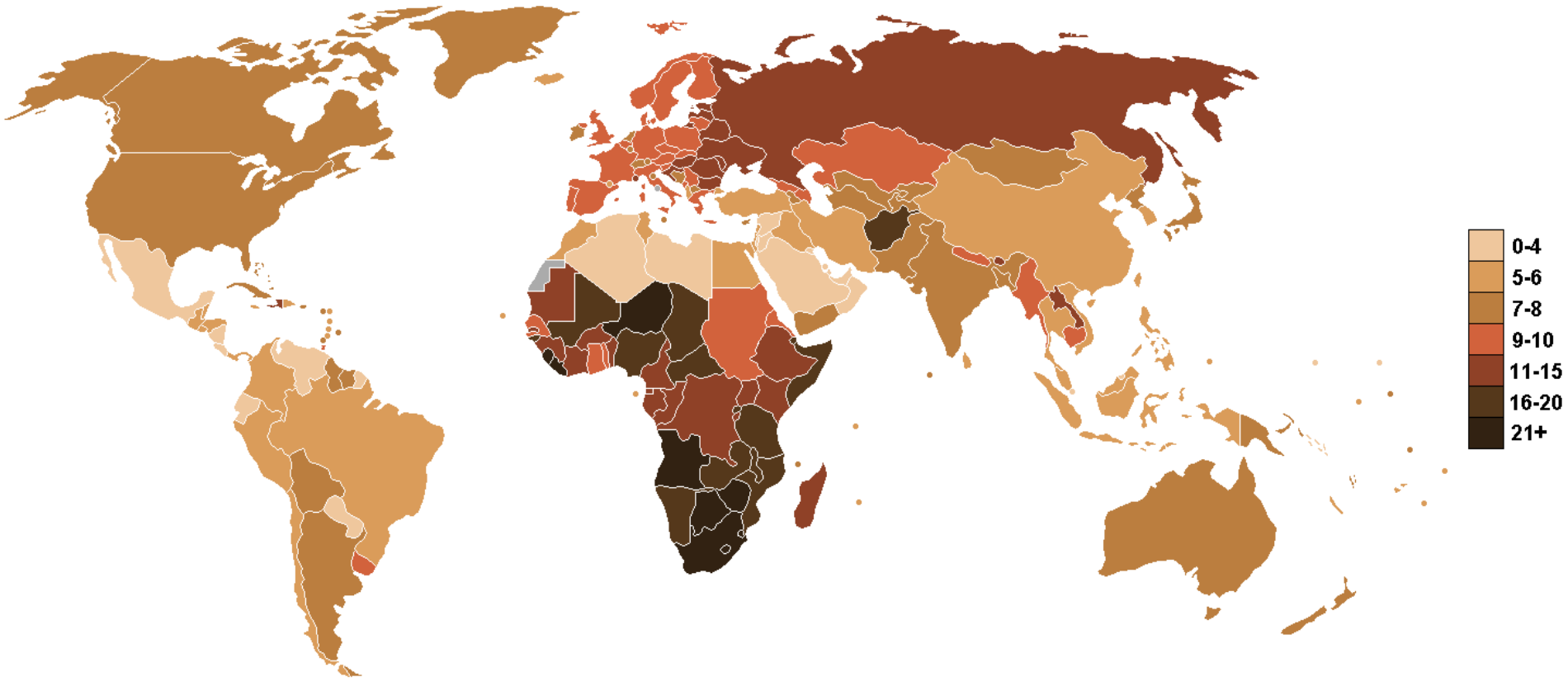
  - growth rates have come down


10000
5000
2000
1000
500
200
100
50
20
10
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
World
Asia
Europe
Africa
Latin America
Northern America
Oceania



World Birth Rates

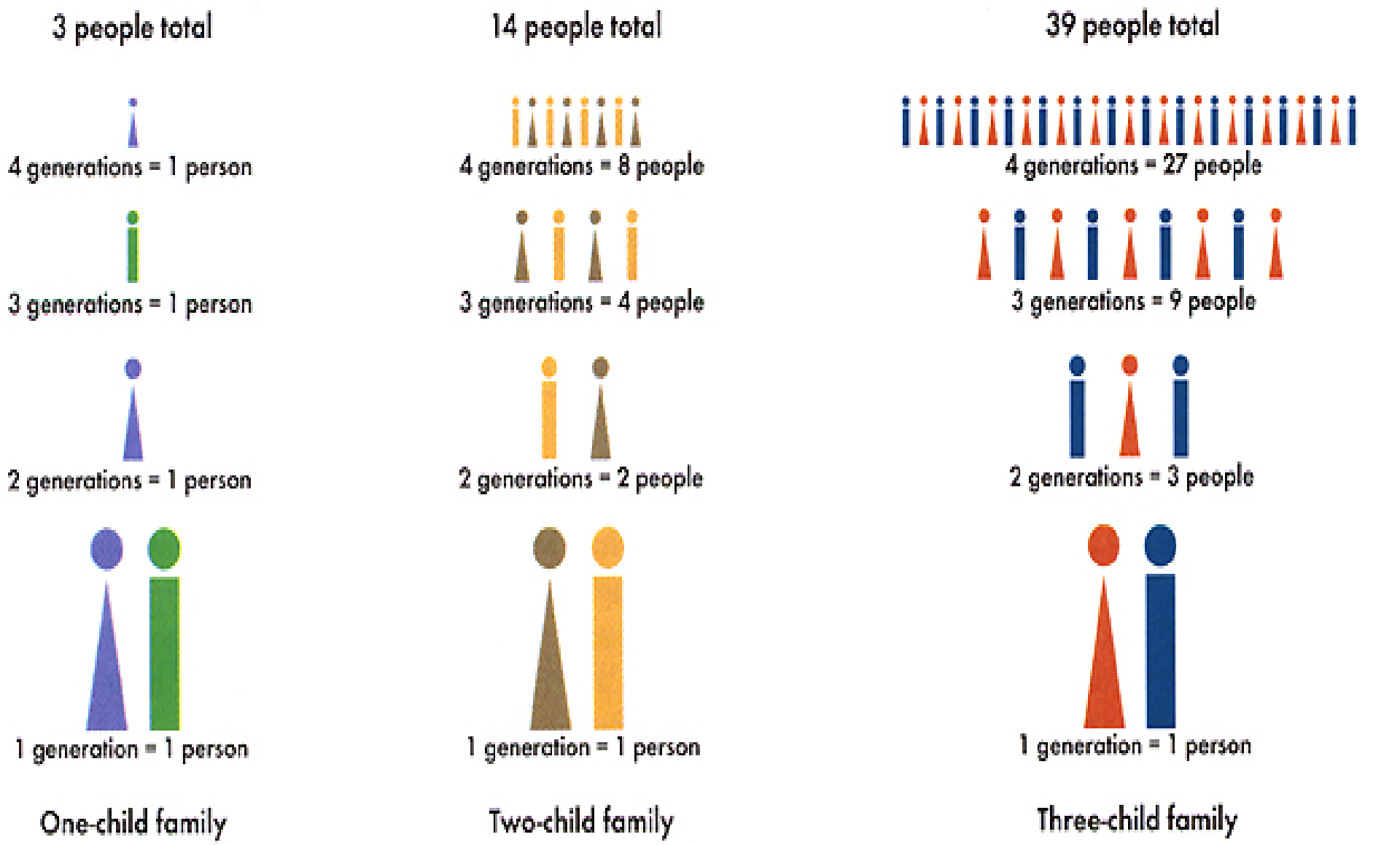
Source: Population Reference Bureau 2009


0-4
5-6
7-8
9-10
11-15
16-20
21+

What Is Family Planning?

A. Definition
   1. Measures enabling parents to control number of children (if they so desire)

B. Goals of Family Planning
   1. Not to limit births
   2. For couples to have healthy children
   3. For couples to be able to care for their children
   4. For couples to have the number of children that they want



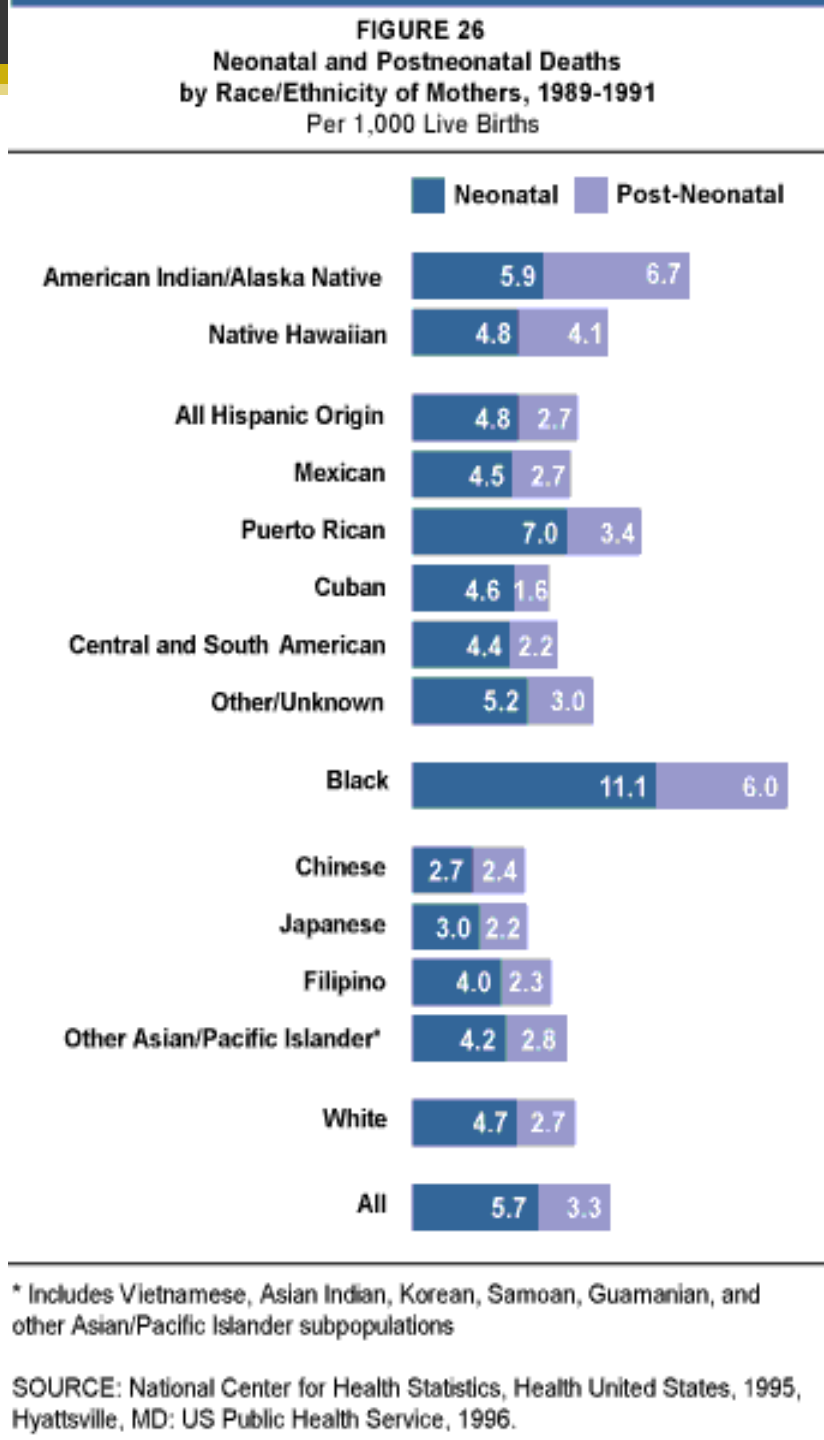
GURE 9-5: The consequences of family size across generations. Imagine that three couples decide to begin families. Couple A wants just one child. their child and grandchild also have just one child, after three successive generations, a total of three people will have been born. Couple B ants two children, as do their children and grandchildren. After three successive generations, 14 people will have been born. Couple C decides have three children, a decision their children and grandchildren share. After three successive generations, 39 people will have been born.

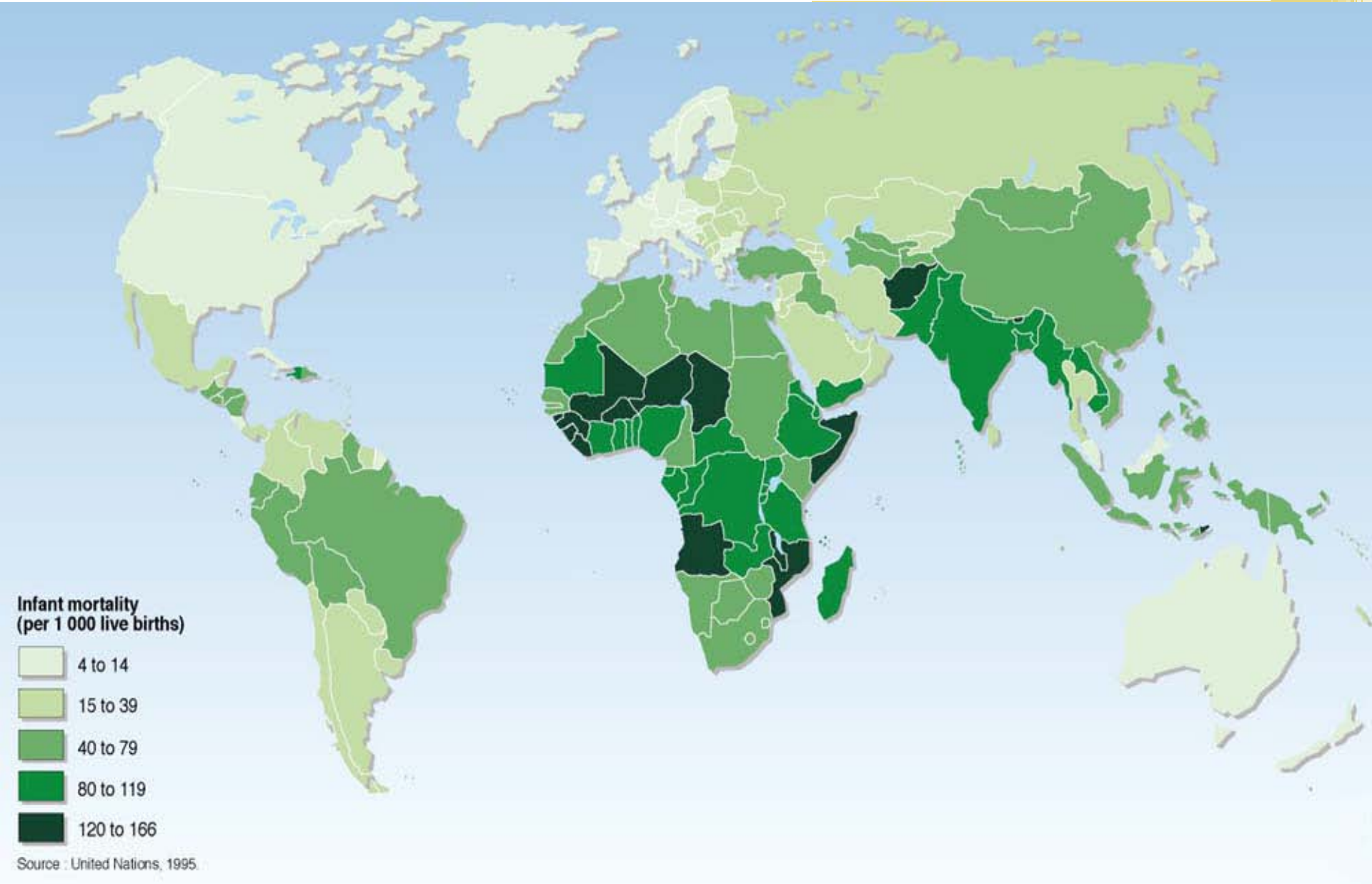
1. China's ProgramNation With Best Known Population Control Program

2. Reasons Chinese Government Initiated Population Control Measures
   a. Freshwater and food at a premium for nation's population
   b. Country experiencing population momentum

3. Government Perks / Coercive Measures for Citizen Compliance
   a. Free education and health care
   b. Increased personal and family incomes
   c. Increased legal marrying age for women
   d. Contraceptives, abortions, and sterilizations free of charge
   e. Preferential housing and retirement income

- infant mortality rate
- IMR
- infant deaths per 1000 live births (infant < 1 yr)
  - 1990: 62 now: 52.4 (normal in 1900: 200)




Infant mortality
(per 1 000 live births)
4 to 14
15 to 39
40 to 79
80 to 119
120 to 166
Source : United Nations, 1995

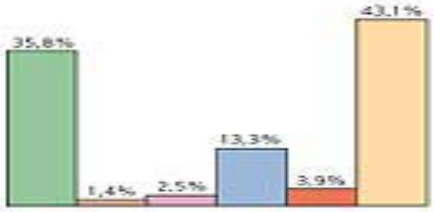
Life expectancy
Years
75
70
65
60
50
0
No data

Which kind of disease dominates in highly developed countries? (respiratory diseases, cancer)
Which kind of disease dominates in developing countries? (infectious and parasitic diseases)

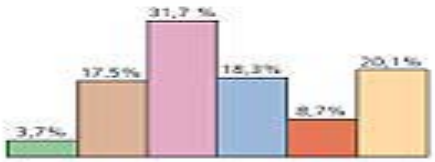
Causes of death

Infectious and parasitic diseases
Cancer
Respiratory system diseases
Circulatory system diseases
Accidents, poisonings,and violence
Other

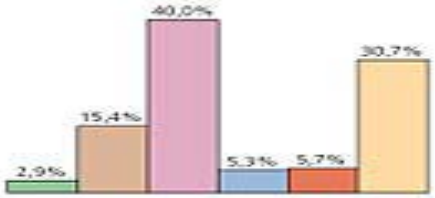
Percentage of all deaths



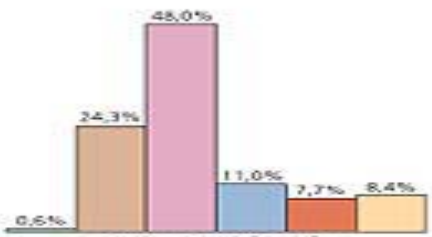
Malawi



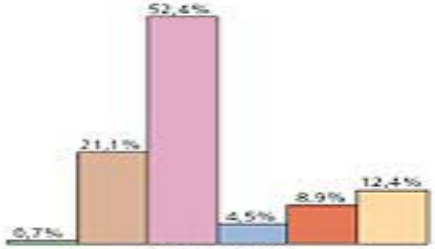
China



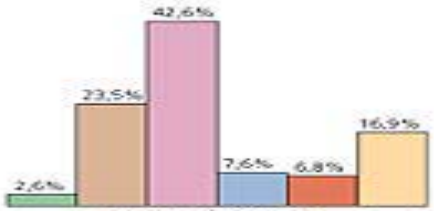
Argentina



New Zealand

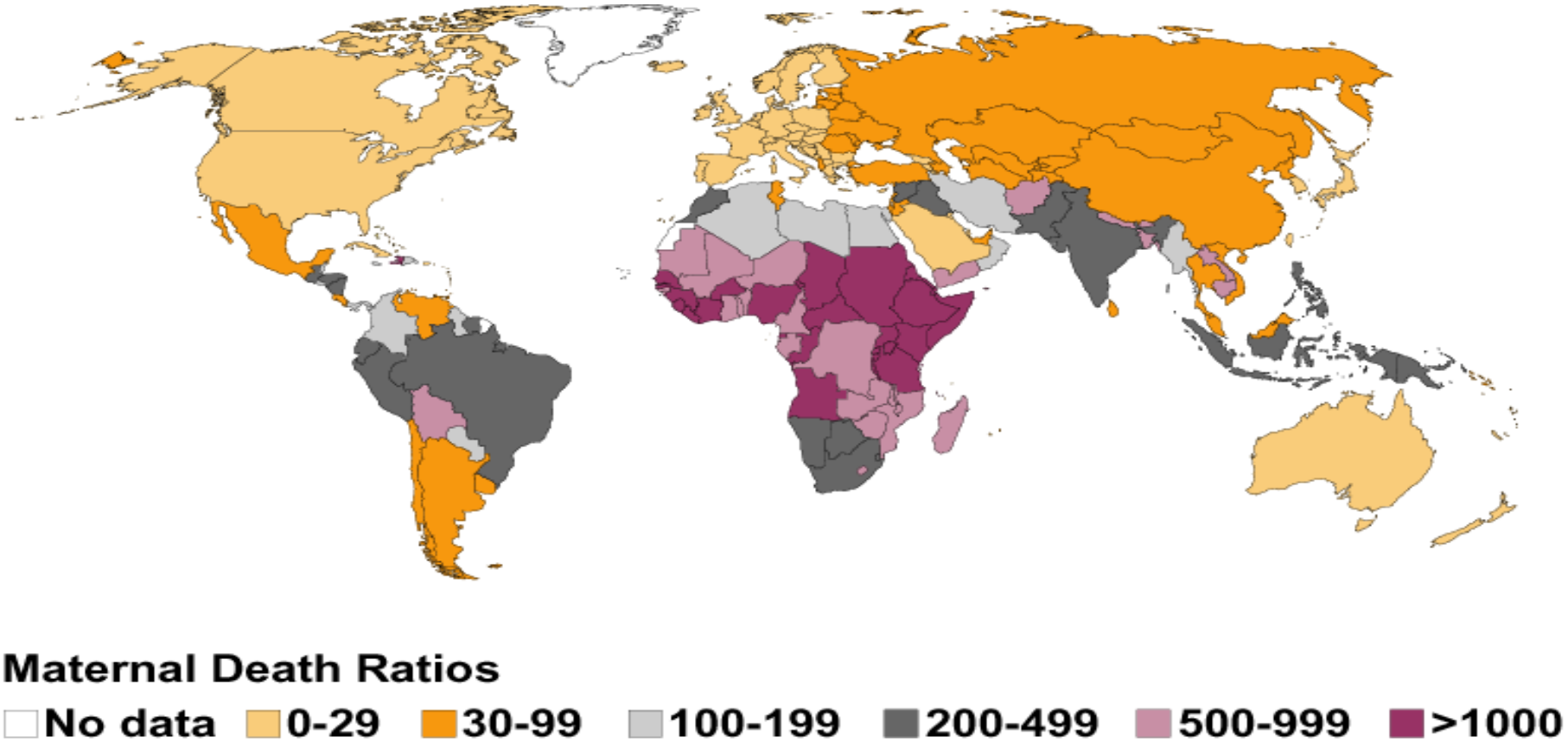


Hungary



United States

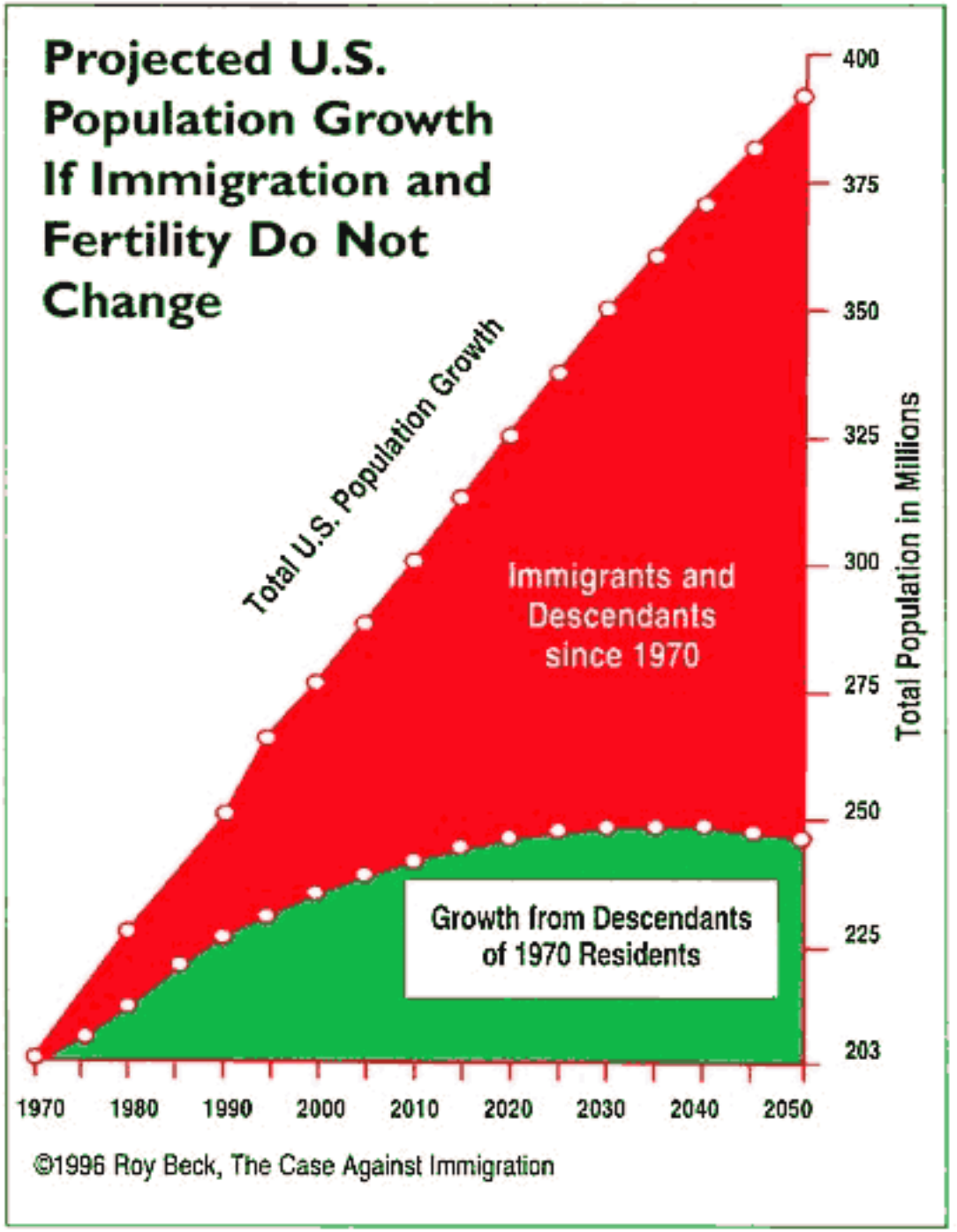
Maternal Deaths per 100,000 Live Births

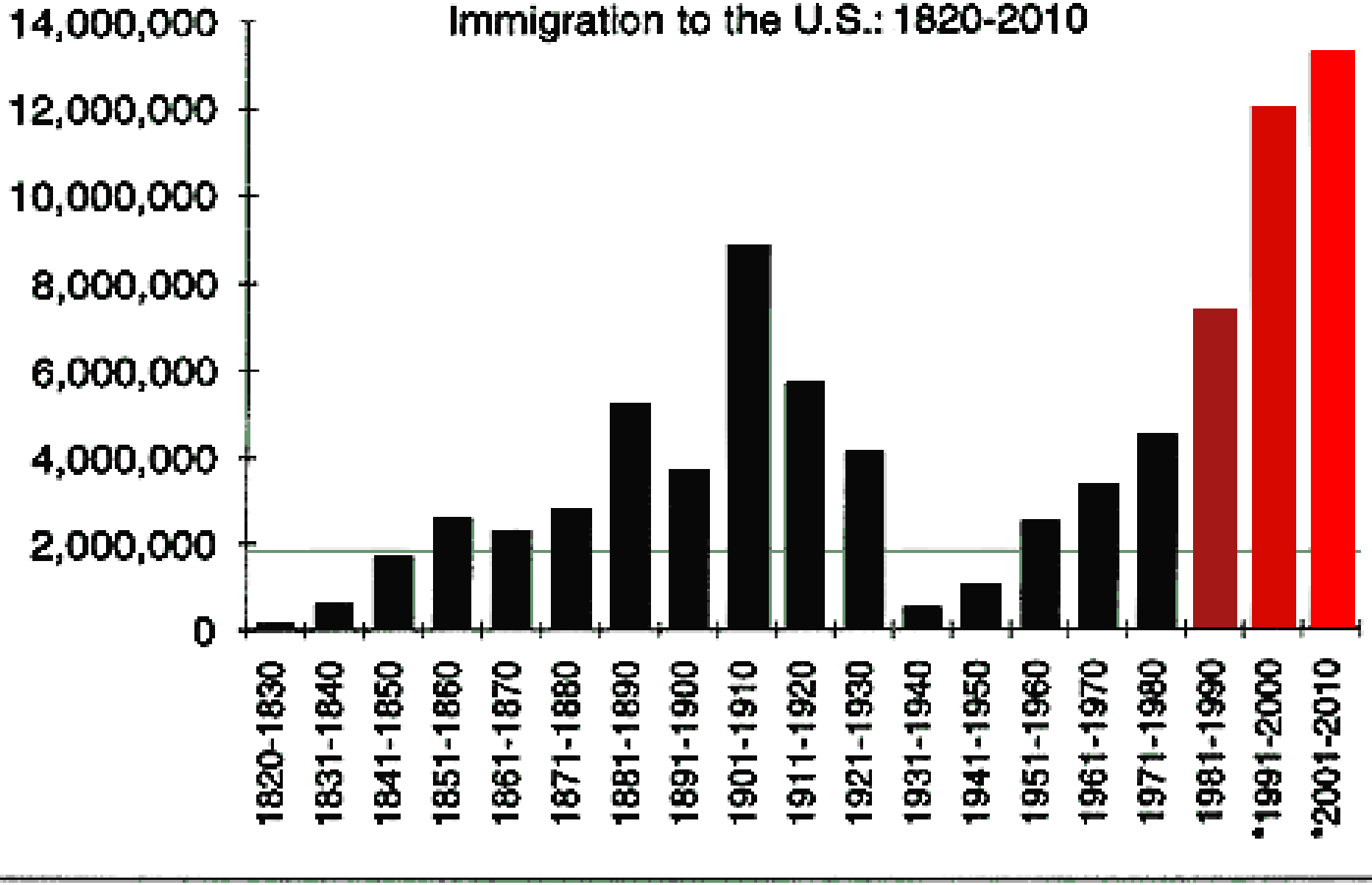


Source: WHO, UNICEF, UNFPA Maternal Mortality in 1995: Estimates Developed by WHO, UNICEF AND UNFPA, 2001.

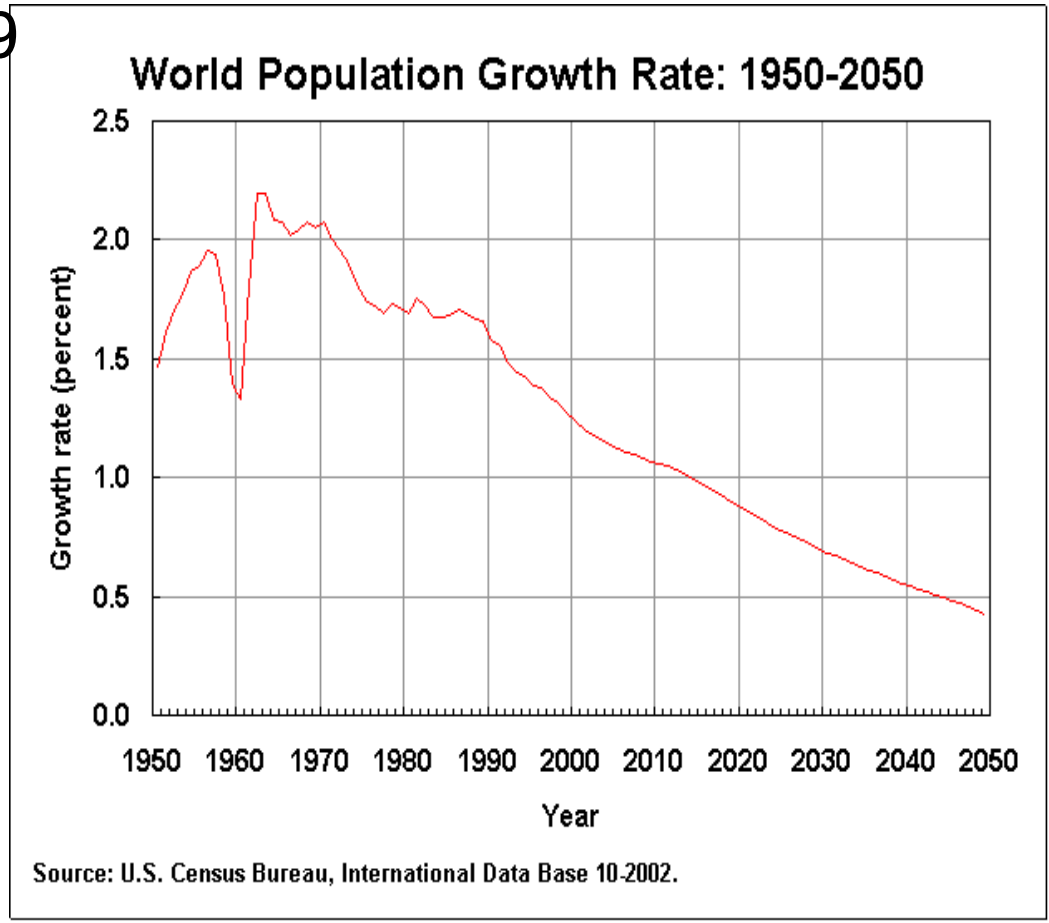
Migration

Net migration is the number of immigrants minus emigrants




Immigration to the U.S.: 1820-2010
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
1820-1830
1831-1840
1841-1850
1851-1860
1861-1870
1871-1880
1881-1890
1891-1900
1901-1910
1911-1920
1921-1930
1931-1940
1941-1950
1951-1960
1961-1970
1971-1980
1981-1990
*1991-2000
*2001-2010

- Overall, the world population is growing at a rate of about 1.19 per cent; if this rate continues, the population will double in 58.82 years.
- Unabated, such a rate would lead to a point about 2000 years hence when the mass of humanity would weigh more, and be larger, than the Earth.
- But, the growth rate is decreasing



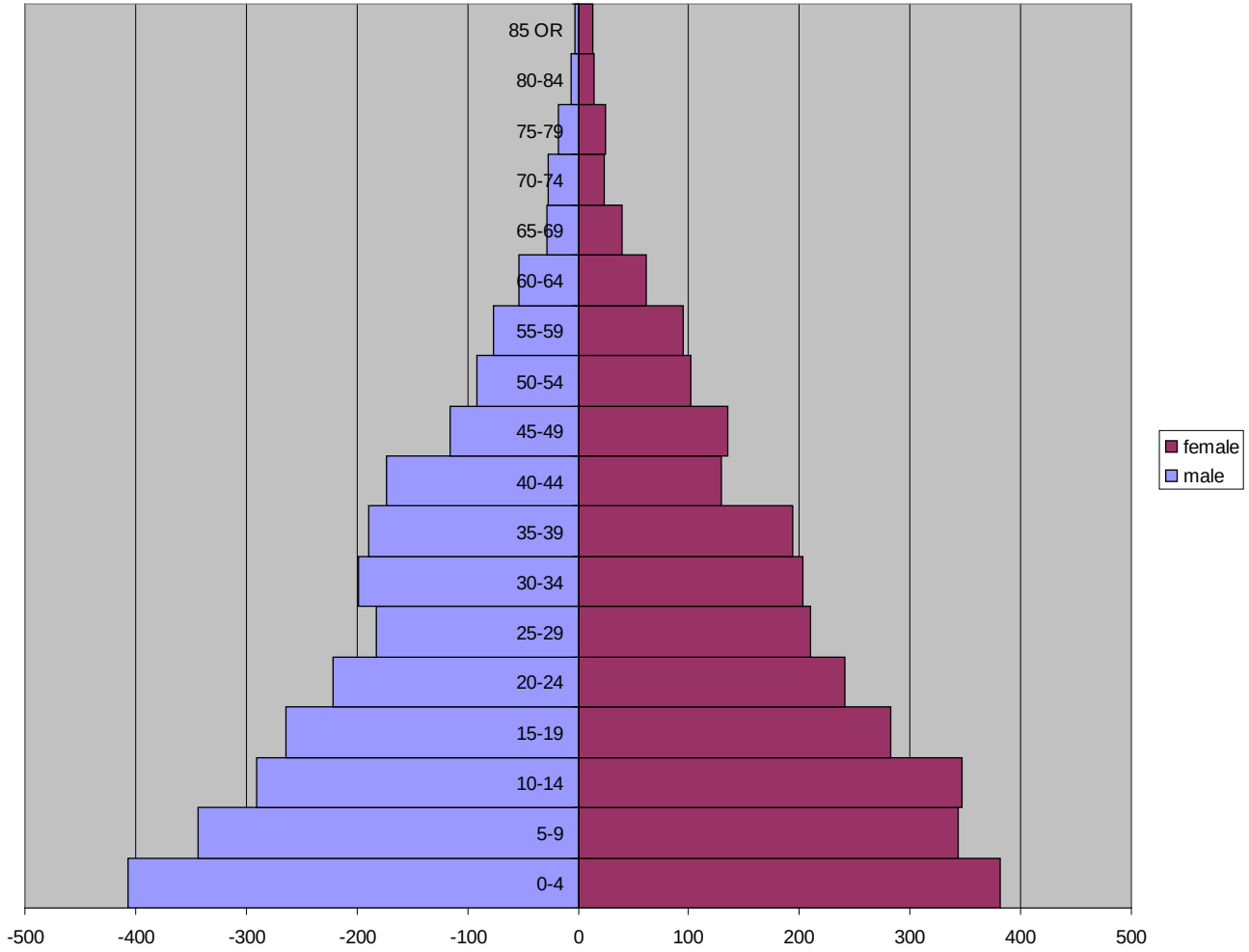
Rule of 70- 70/ Growth Rate

Population Age Structure

Population Pyramids

- Graphic device: bar graph
- shows the age and gender composition of a region
- horizontal axis: gender
  - male: left-hand female: right-hand
  - absolute number of people or %
- vertical axis: age
  - 5-year or 10-year age groups

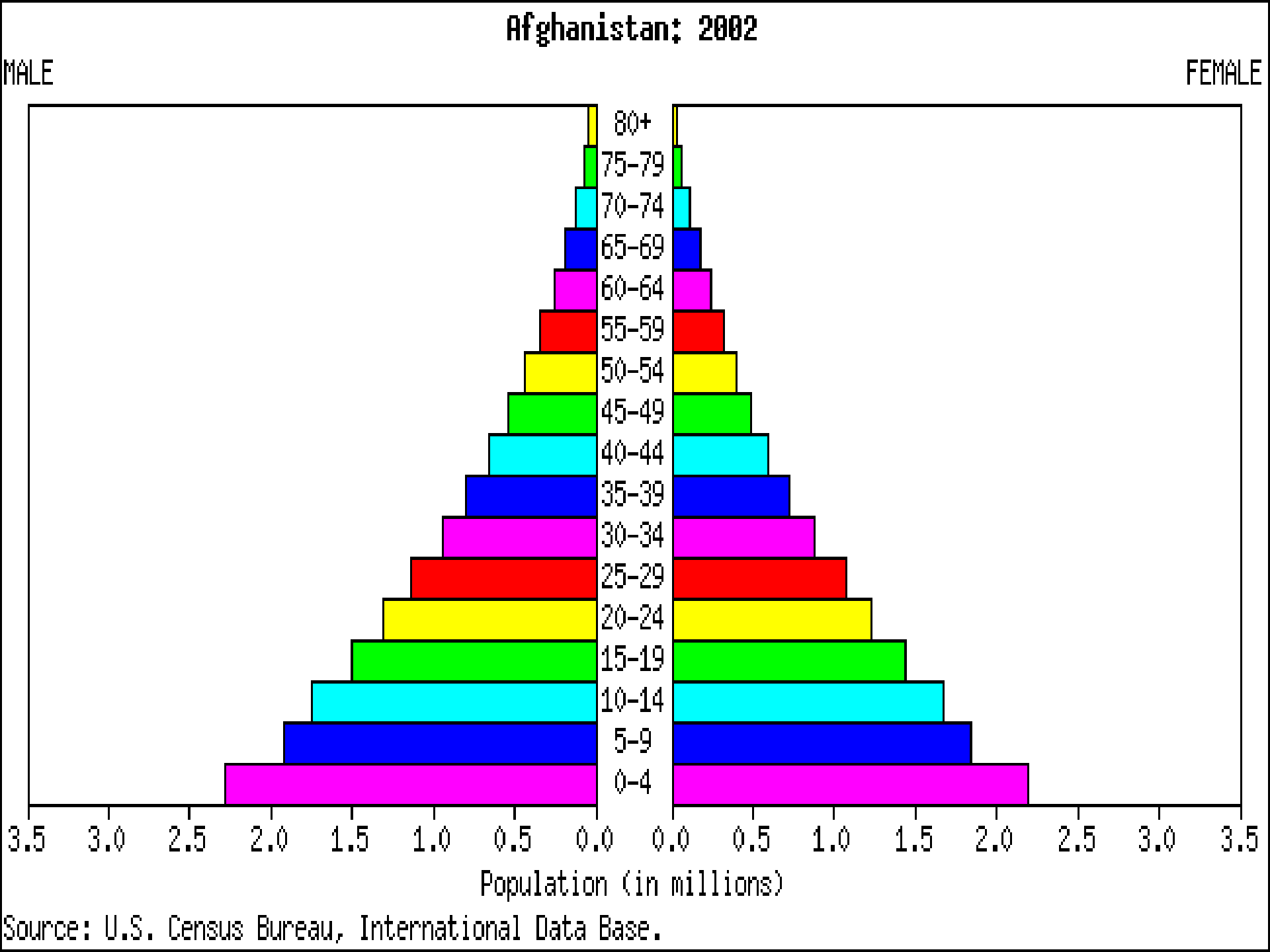
Population Pyramid with young cohorts

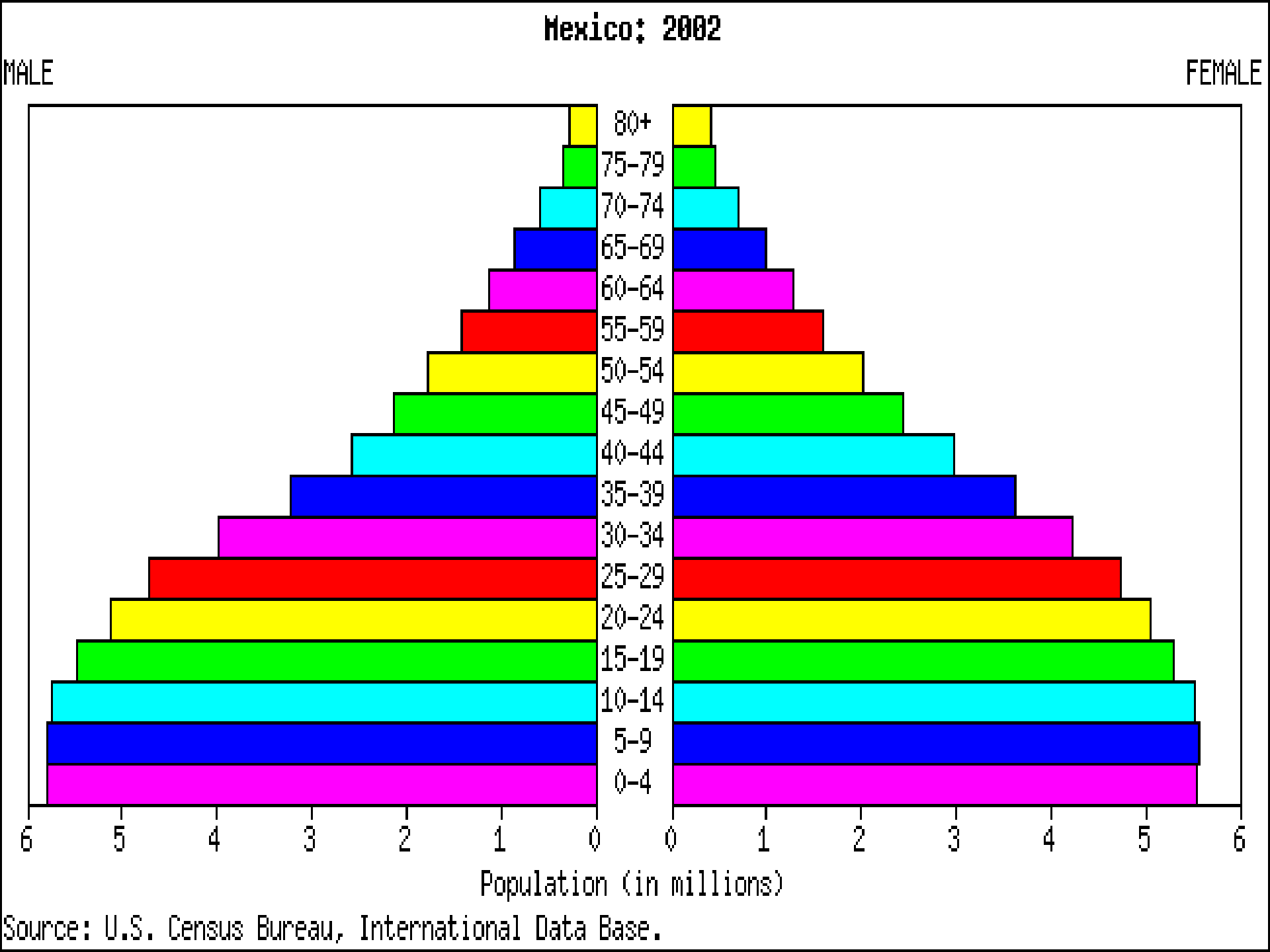


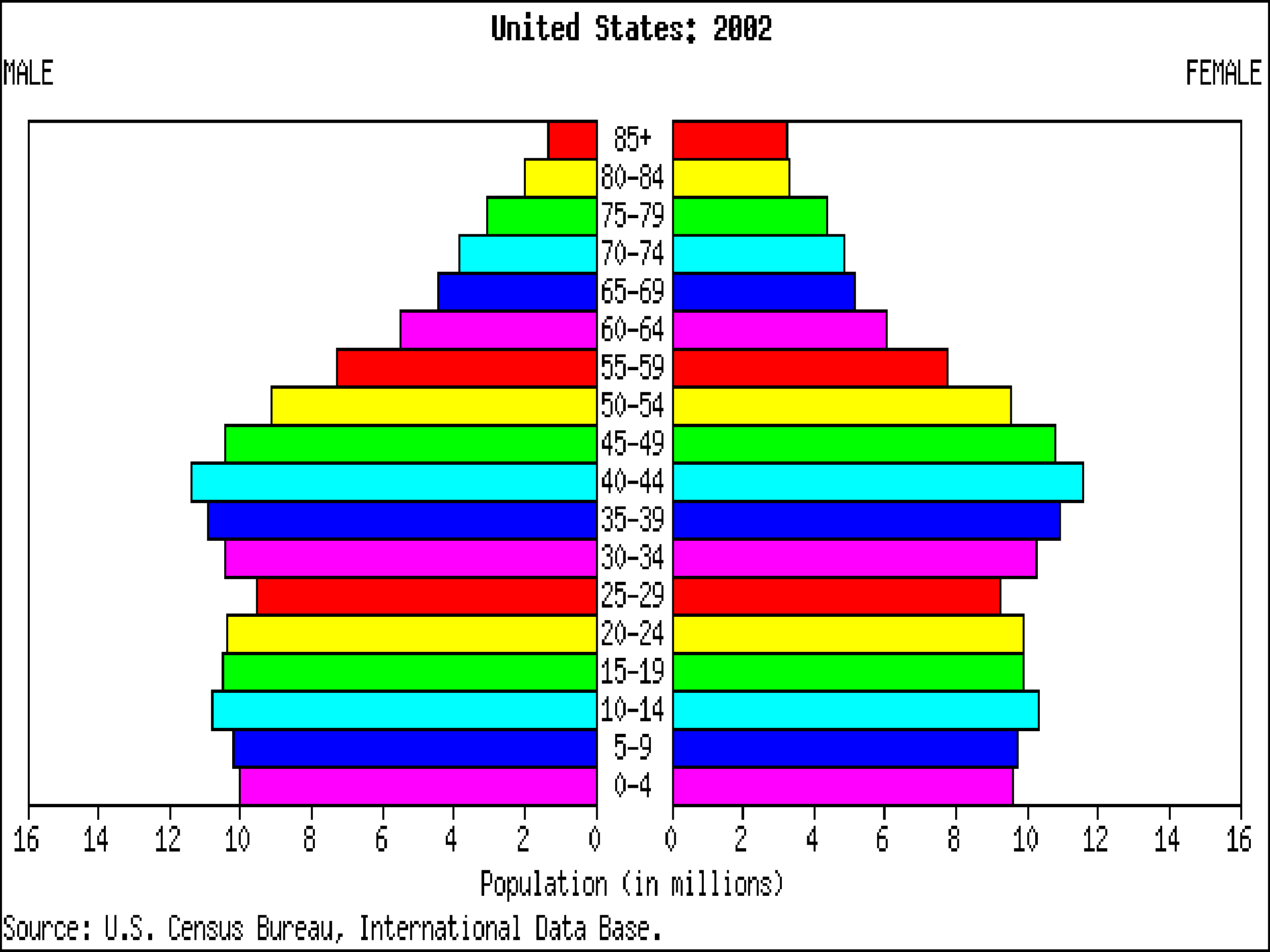
Trends in Population Pyramids

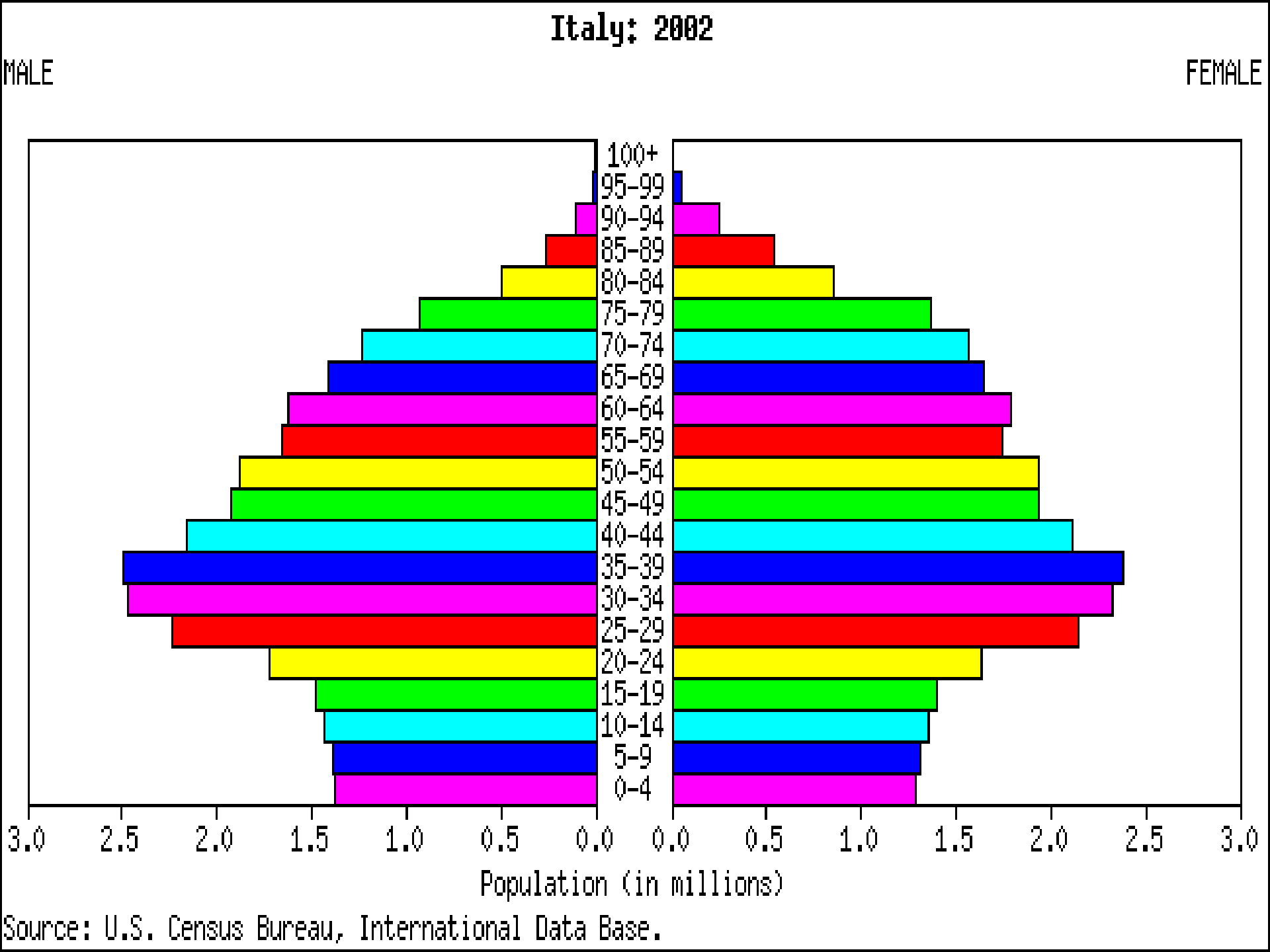
- Population Pyramids on the Web

- **High Growth**: Afghanistan
- **Moderate Growth**: Mexico
- **Zero Growth**: U.S.
- **Negative Growth**: Austria or Italy


Afghanistan: 2002
MALE
FEMALE
80+
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
5-9
0-4
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Population (in millions)
Source: U.S. Census Bureau, International Data Base.


Mexico: 2002
MALE
FEMALE
80+
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
5-9
0-4
6
5
4
3
2
1
0
0
1
2
3
4
5
6
Population (in millions)
Source: U.S. Census Bureau, International Data Base.

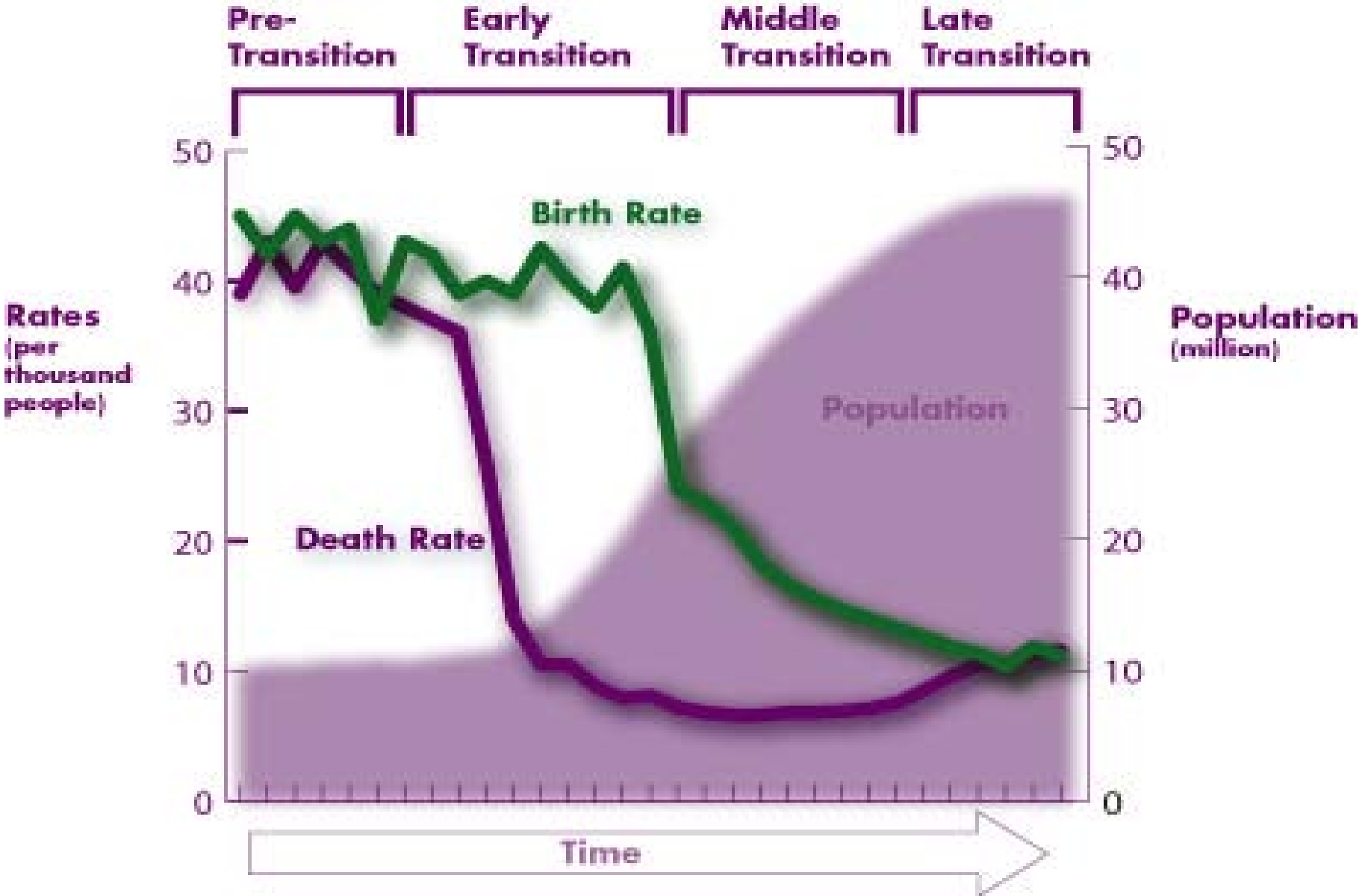

United States: 2002
MALE
FEMALE
85+
80-84
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
5-9
0-4
16 14 12 10 8 6 4 2 0
0 2 4 6 8 10 12 14 16
Population (in millions)
Source: U.S. Census Bureau, International Data Base.


Italy: 2002
MALE
FEMALE
100+
95-99
90-94
85-89
80-84
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
5-9
0-4
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Population (in millions)
Source: U.S. Census Bureau, International Data Base.

Demographic Transition

- Movement of a nation from high population growth to low population as it develops economically
- Transition as a result of four stages
  - Stage 1—Birth and death rates are both high
  - Stage 2—Death rates fall; birth rates remain high; growth rate rises
  - Stage 3—Birth rates fall as standard of living rises; growth rate falls
  - Stage 4—Growth rate continues to fall to zero or to a negative rate

The Demographic Transition

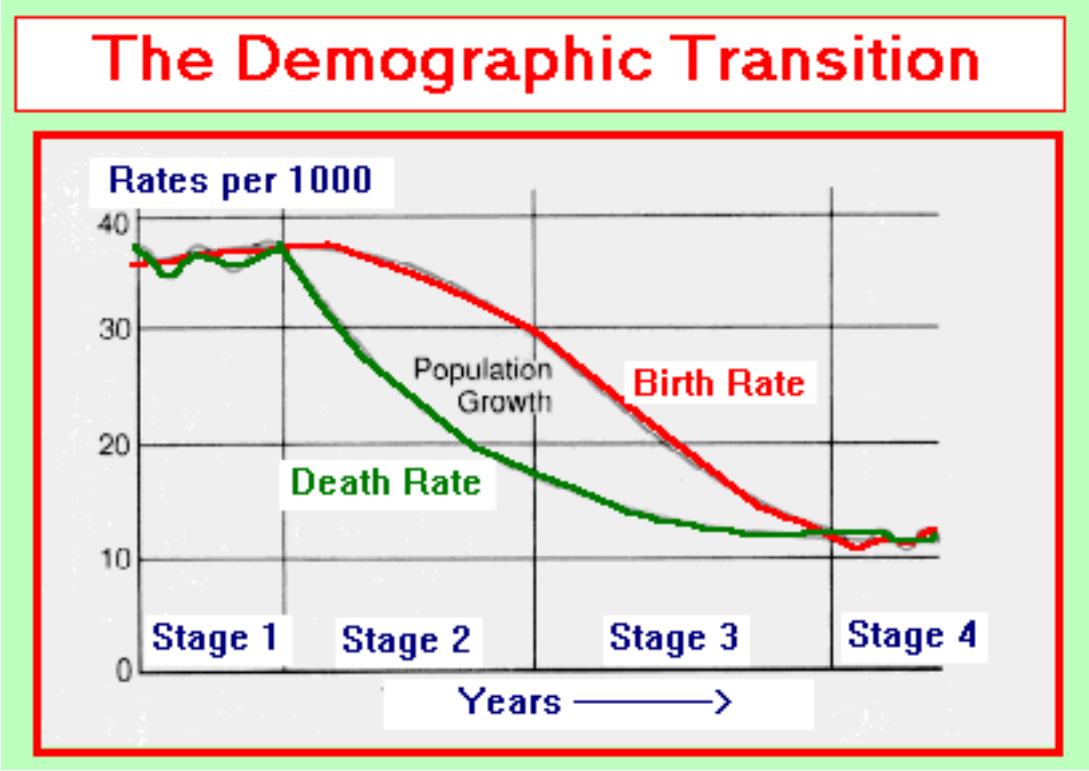


Five Stages of the Demographic Transition

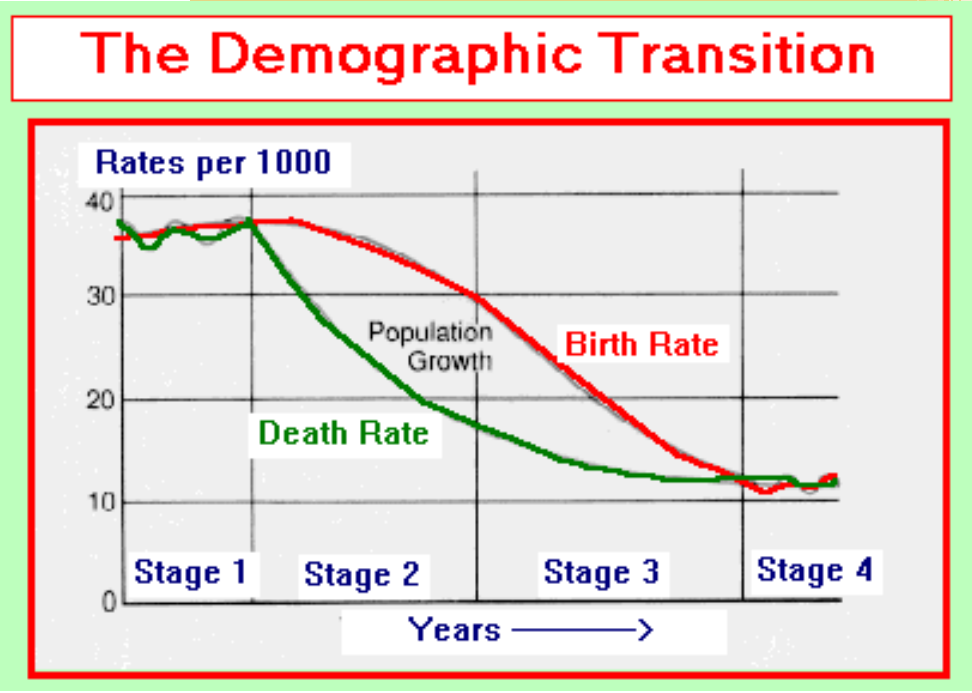
- Used to be 4, now 5 stages
- birth rates, death rates and growth rates systematically change through time as societies change:
  - modernize, urbanize
  - gain access to technology

Stage 1

- high birth rates, high (at time erratic) death rates, low growth rates
- stage for much of human history, traditional societies
- practically no country today



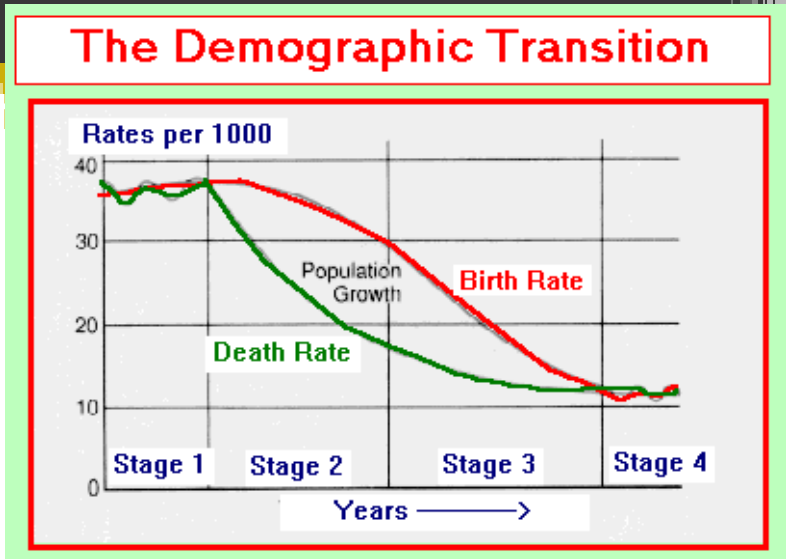
Stage 2



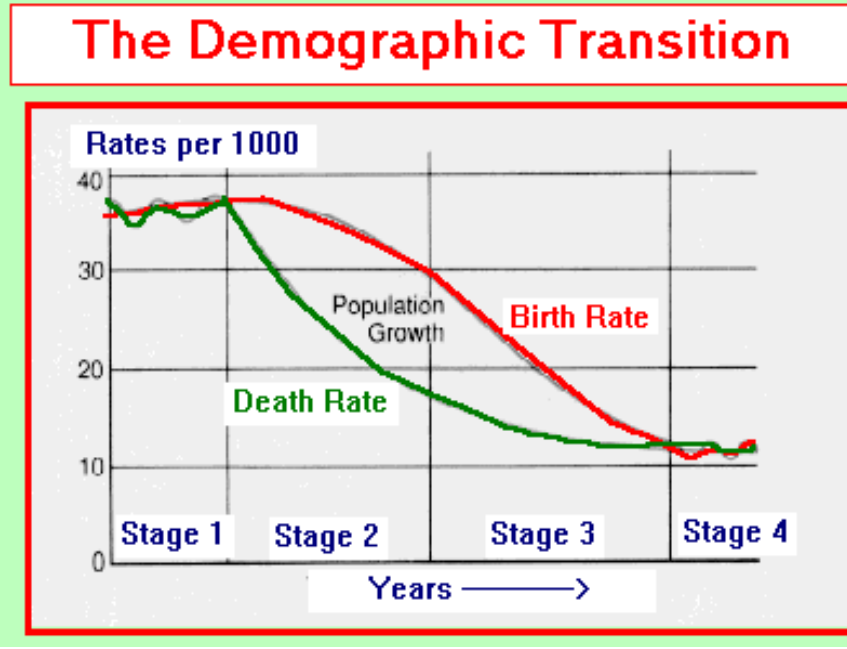
- high birth rates, declining death rates, rising growth rates
- improvements in sanitation (water) and medicine
- in Europe during Industrial Revolution
- in developing countries since the 50s/60s
- much of Africa today, some countries of Asia (Afghanistan, Nepal, etc.)

Stage 3

- continued decline of death rates, declining birth rates,
  growth rates decline from high to lower levels
- change in behavior: adaptation to lower death rate, in particular infant mortality rate
- economic change: urbanization (incentive to have fewer children)
- Mexico today



Stage 4 & 5



- Stage 4: low birth rates, low death rates, low growth rates
  - United States today
- Stage 5: low birth rates, rising death rates, declining growth rates (if birth rates drop below death rates: negative growth rates)
  - several countries of Europe today (Austria)

Demographic Trap

- Population Path of Most Less-Developed Countries (LDCs)
- “Trapped” in Stage 2 of Demographic Transition
  - Before 1970, LDCs seemed poised to make transition thanks to economic growth
  - Since 1970, economic growth has not kept pace with population
  - High birth and low death rates result in explosive population growth
  - Downward spiral in standard of living

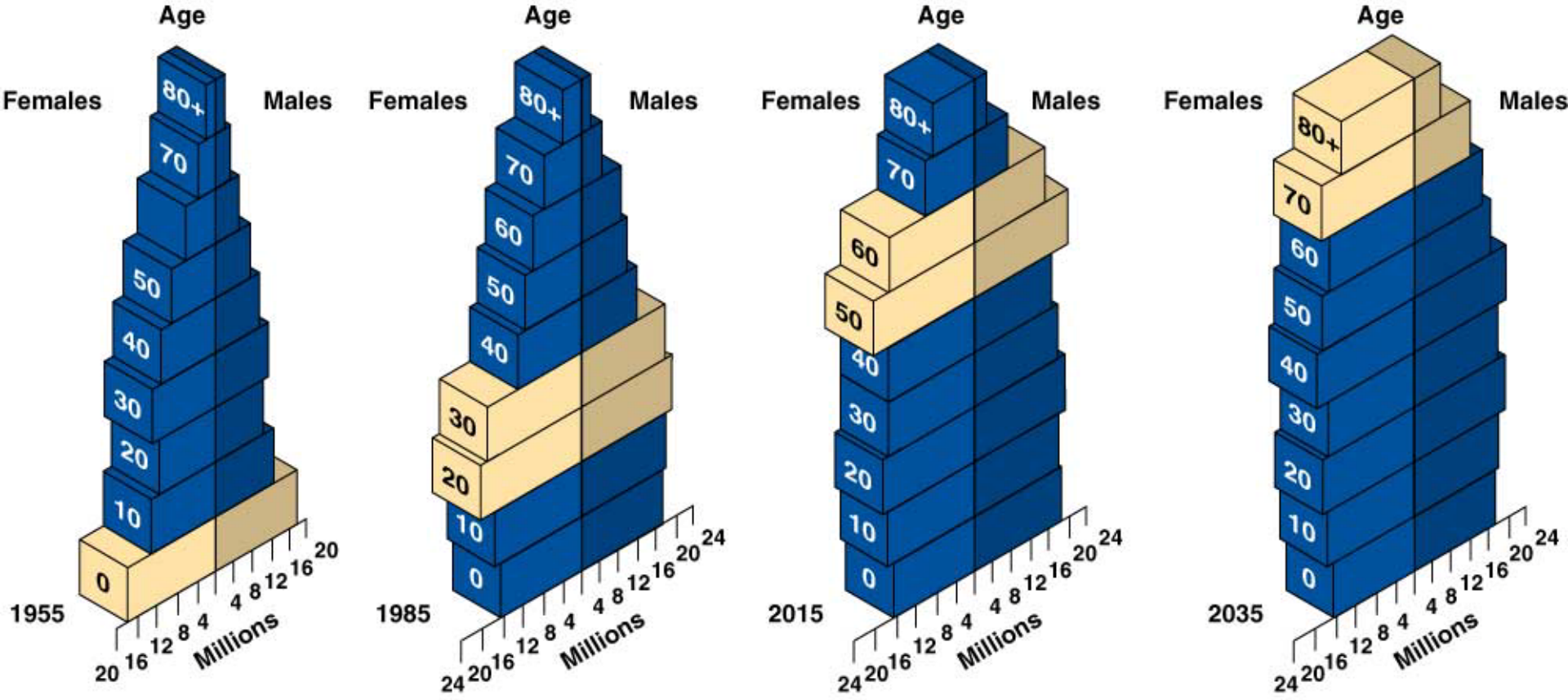
Demographic Fatigue

- Condition characterized by a lack of financial resources and an inability to deal effectively with threats such as natural catastrophes and disease
- Possibility that countries suffering from demographic fatigues could slip back into Stage 1 of demographic transition

Age Structure & Population Projections

- Baby boomers - half of U.S. population; use most of goods and services; make political and economic decision
- baby-bust generation - born since 1965; may have to pay more income, health care and social security to support retired baby boomers; but face less job competition
- Better health may --> later retirement of baby boomers --> keep high-salary jobs

Tracking the baby-boom generation in the United States

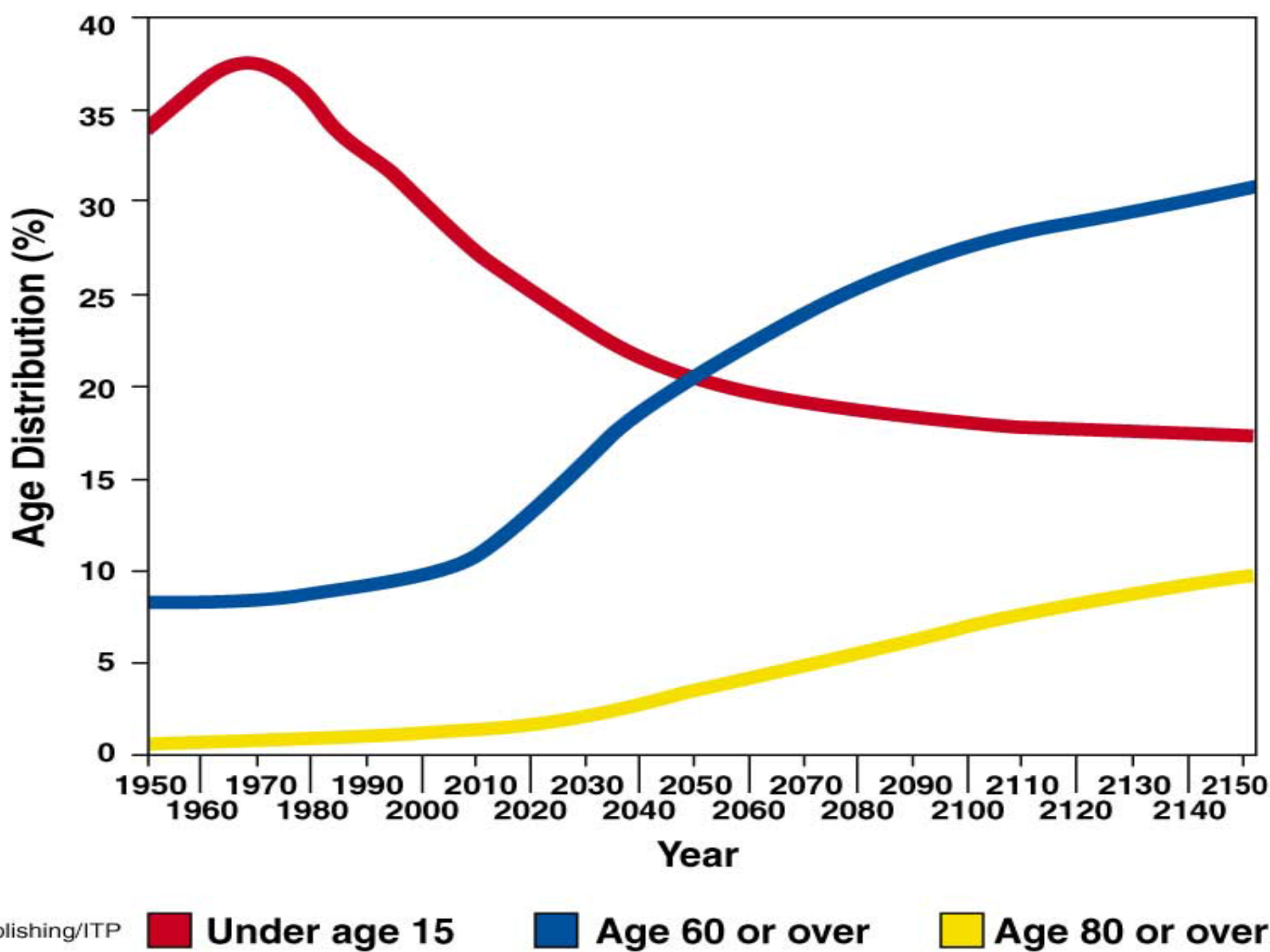


Population Size

Strategies for sustainability, case studies, national policies

Effects of Population Decline

- As percentage of 60+ aged people increases, population begins decline
- 60+population increase --> severe economic and social problems because 60+ consume
  - more medical care
  - Social Security
  - costly public services
- Labor shortages require automation & immigration

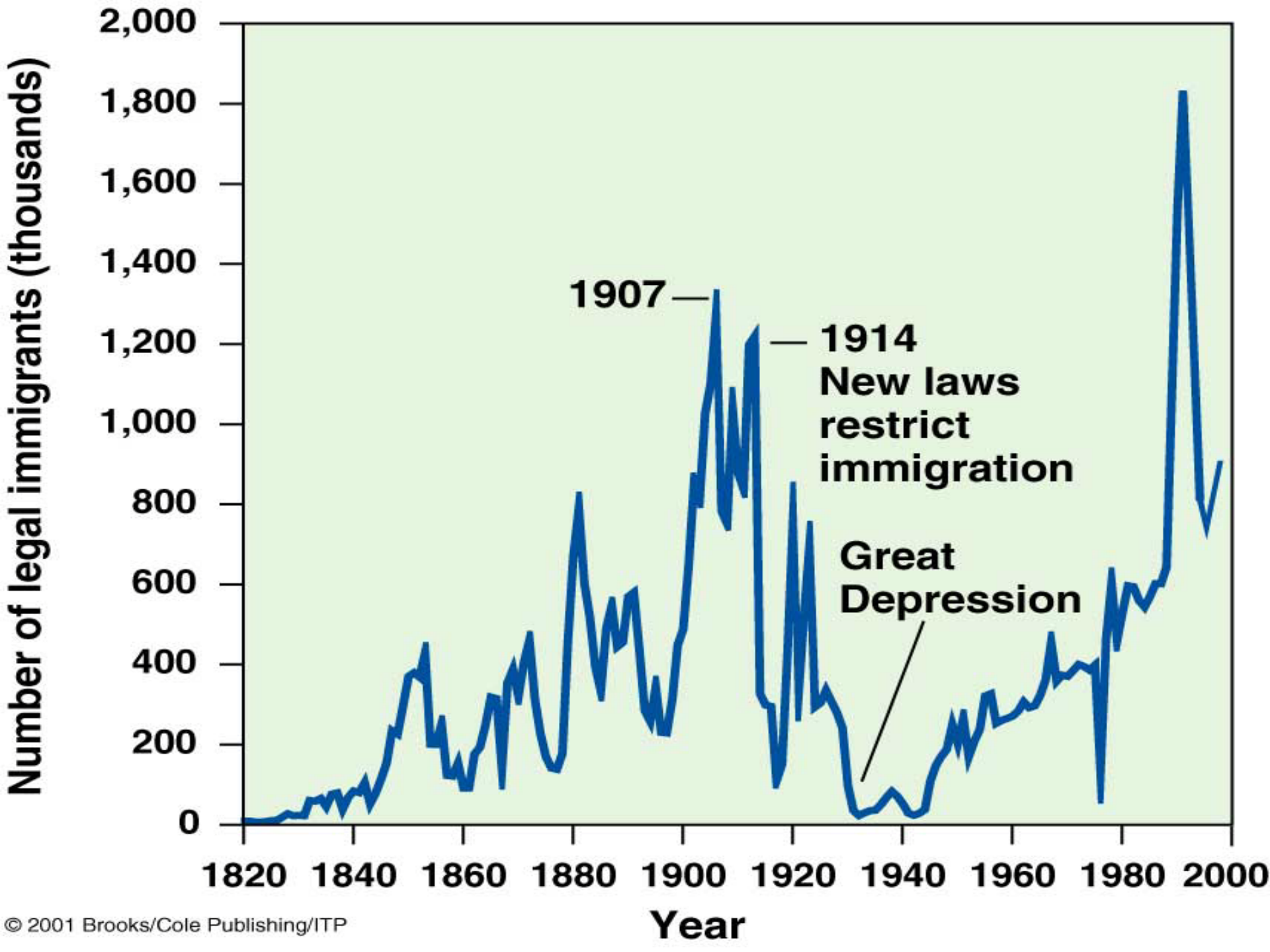


The Graying of Japan

- Family-planning access, cramped housing, expensive land, late marriage, education cost --> voluntary decrease in birth rate
- Low immigration rate
- Health insurance and pension - 45% of national income; could -->low economy
- Illegal immigration bolsters work force

Influencing Population Size

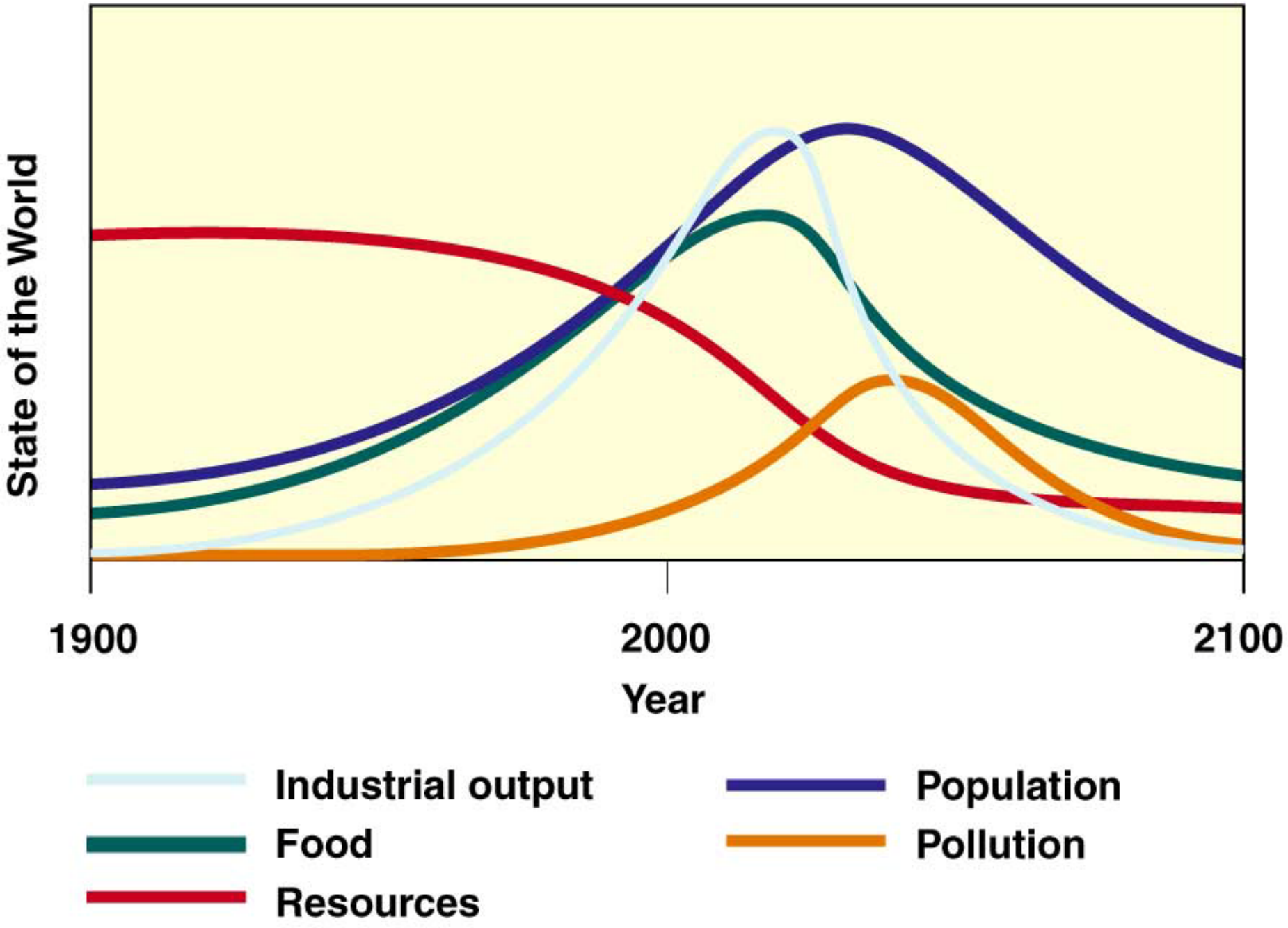
- Most countries restrict immigration
  - Canada, Australia, U.S. - most immigration
- Involuntary immigration results from
  - armed conflict
  - environmental degradation
  - natural disaster --> environmental refugees
- ~1% of developing nations pop. Emigrates
- Migration from rural to urban areas

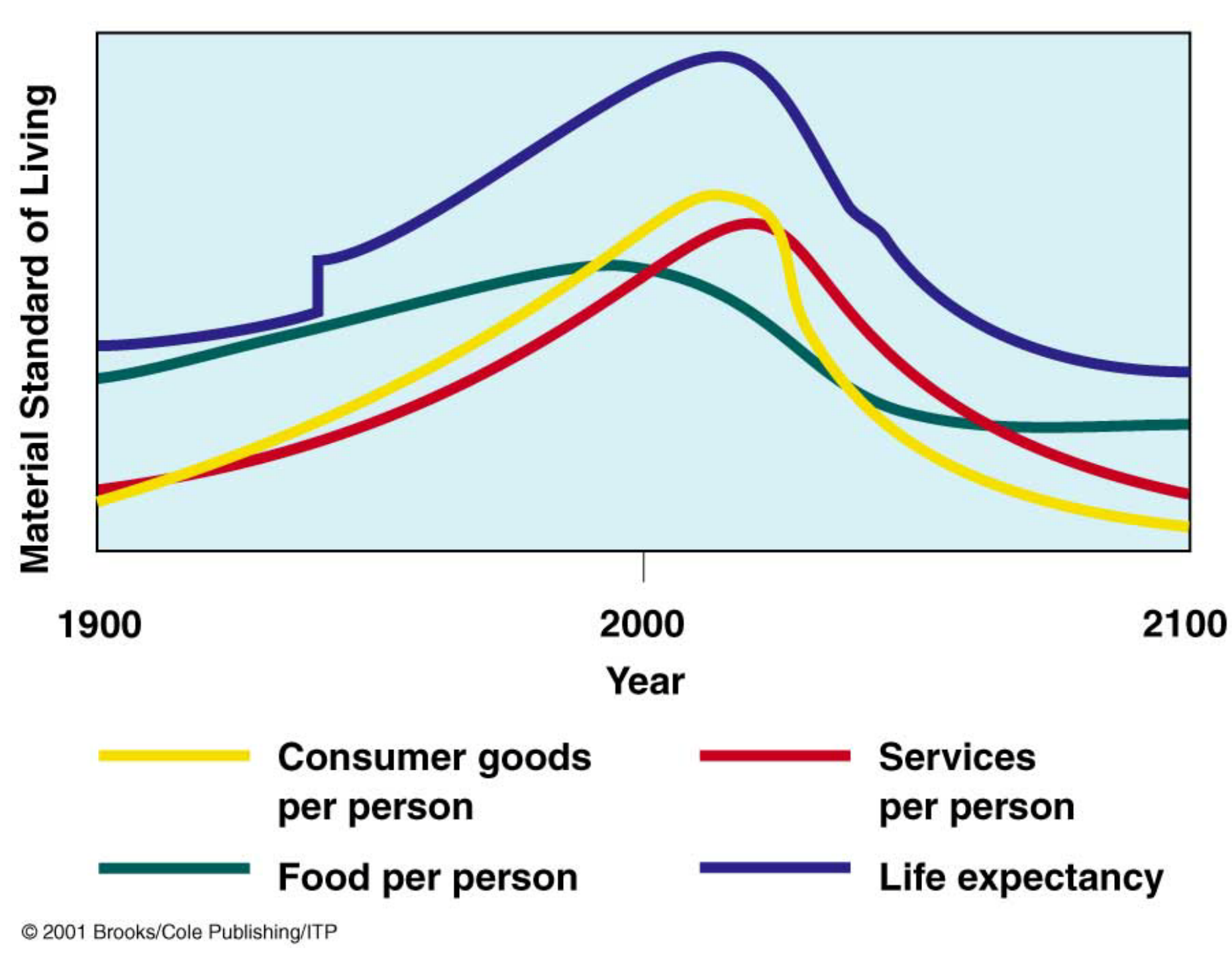


Pros and Cons - reducing births

- Fertility reduction programs consume less than1% of national budgets
- Controversy exists over whether earth can provide adequate care for 3 billion people without massive environmental damage
- Economists encourage population growth
  - consider people as valuable resource
- No agreement on optimum sustainable population

- Population regulations violate religious beliefs; population growth --> power
- but population growth is threat to earth's life support systems
- Should people have freedom to produce as many offspring as desired? or
- Will more offspring reduce quality of other people's lives?

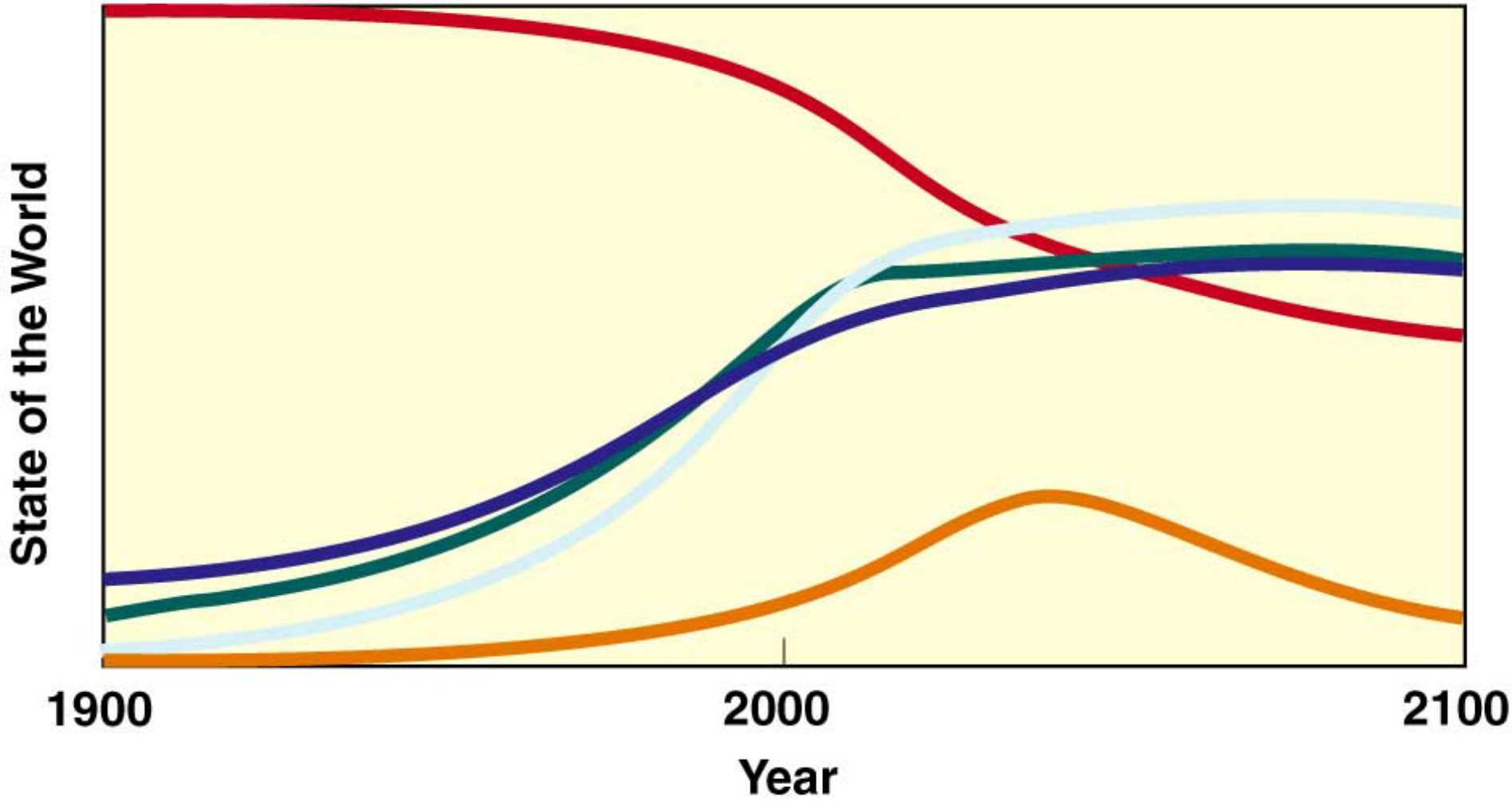


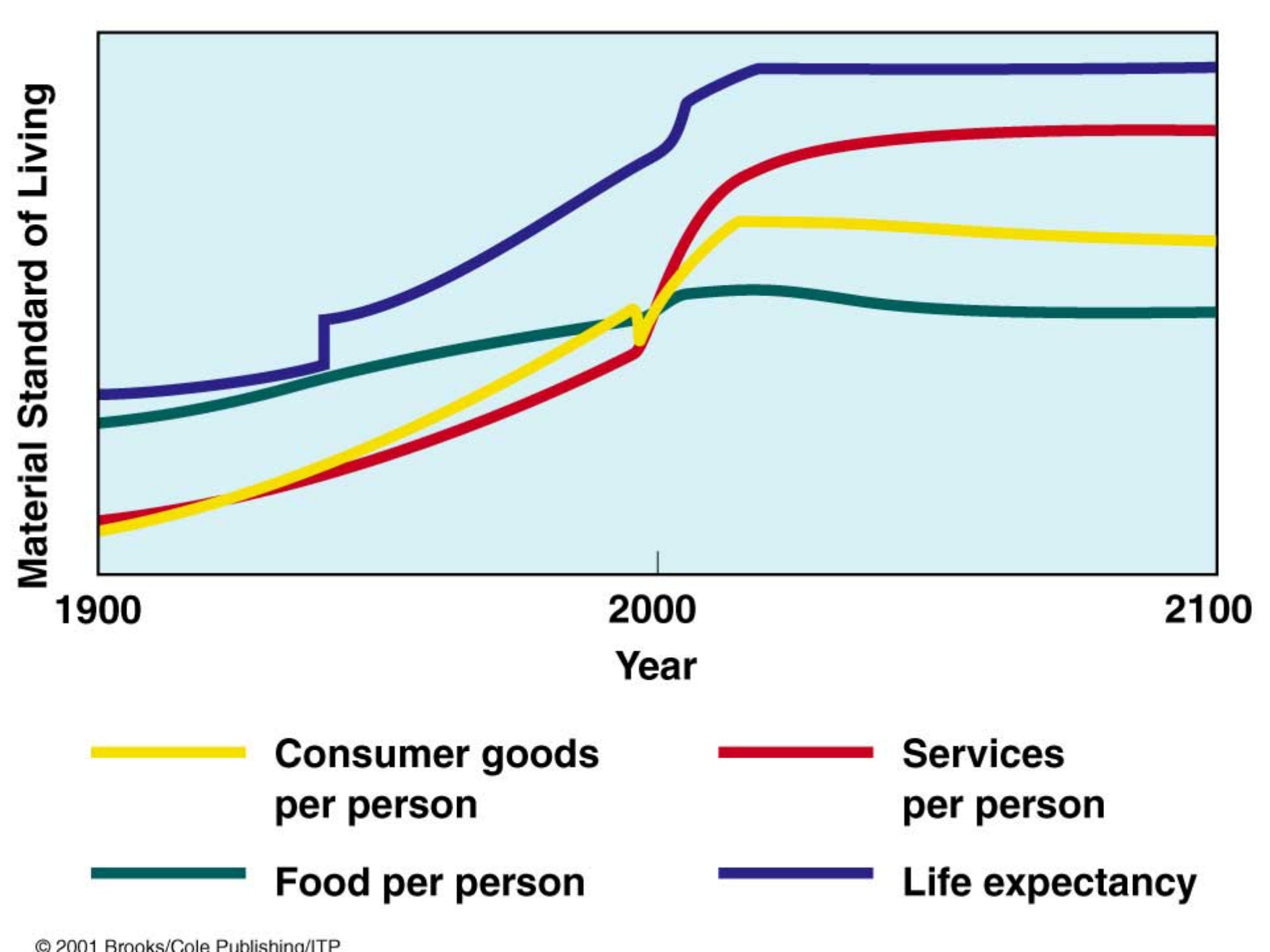


Pros and Cons: Reducing Births

- U.S. National Academy of Sciences and the Royal Society of London:
- “Though population growth may not be the only cause of environmental and resource problems, there is need for drastic changes to prevent accelerating environmental decline and then a rise in death rates, so…”

- If technology helps to double supplies of nonrenewable resources and
- if 100% effective birth control is available to everyone and
- if no couple had more than 2 children after 1995 and
- if per capita industrial output stabilized at 1990 levels, **then**



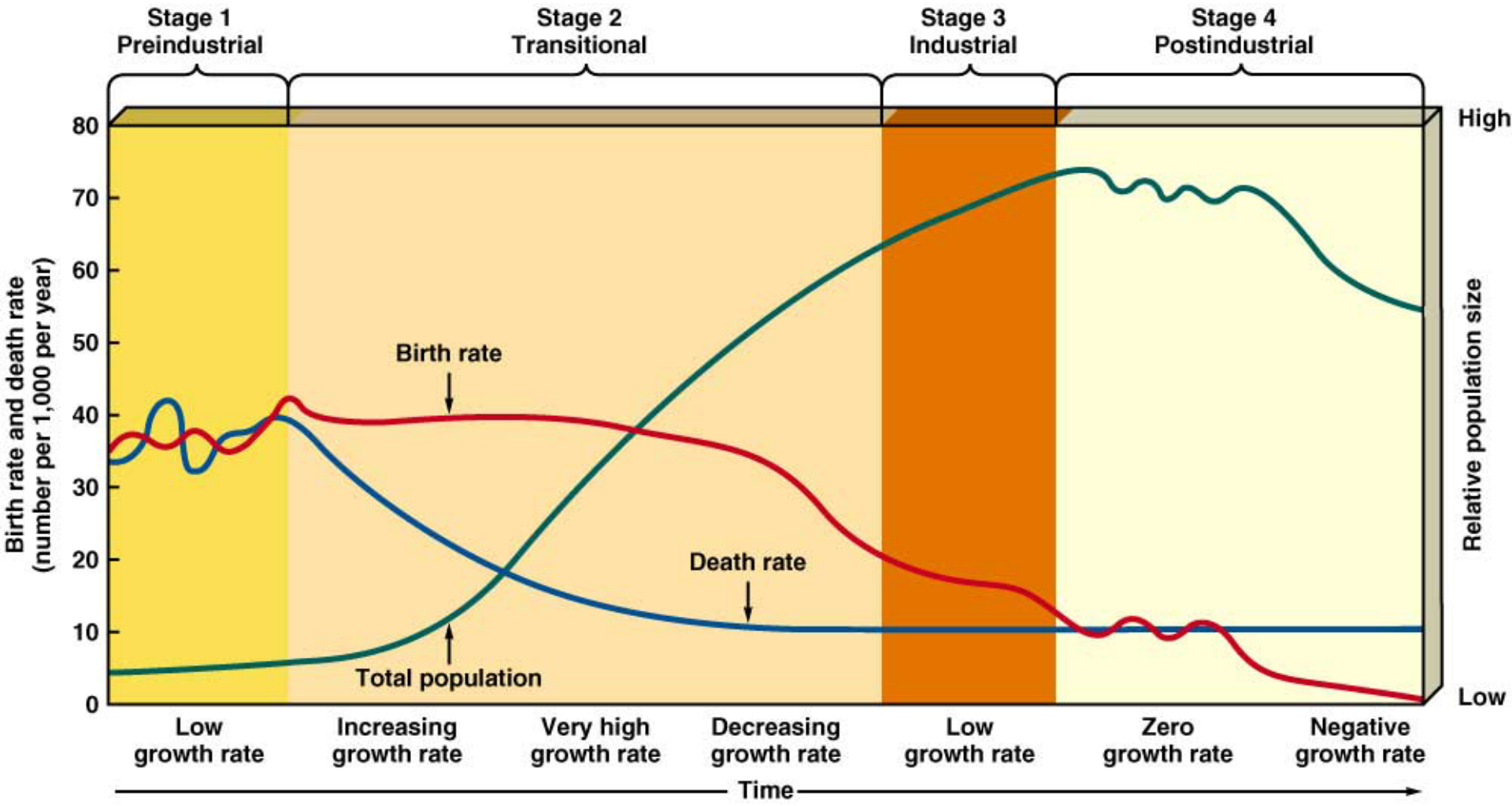


Economic development and birth rate reduction

- Demographic transition - a hypothesis of population change - As countries become industrialized, their birth rates decline
  - Preindustrial - harsh living conditions, high birth rates & infant mortality, high death rates
  - Transitional - higher food production, better health care, death rate drops but birth rate high
  - Industrial - birth rate drops: birth control and lower infant mortality; better economics

Economic development and birth rate reduction

- Post-industrial - birth rate drops to death rate; sustainable economic development
- Developing countries remain in transitional stage
- Demographic trap - continuing population growth, in spite of fertility decline, overwhelms local life-support systems
- Developing countries lack skilled workers needed to make transition; national debts



Family Planning: reduce births and abortions

- 59% contraceptive use in developed countries -46% overall, up from 10% in 60s
- FP reduces children's social services needs
- FP reduces risk of childbearing deaths
- FP effectiveness depends on program design and funding:
  - good in some counties with good program
  - poor in other counties

Family Planning: reduce births and abortions -2

- Services not always accessible; add female teenagers and sexually active unmarried
- Add birth control for men (sperm-killing device used in China)
- If developed countries provided $17 billion/ year, and each person pays $4.80/year, average family size would be 2.1 and world population would be 2.9 billion

Rewards and Penalties to reduce births

- What might work:
  - encourage, rather than coerce, people to have fewer children
  - reinforce existing customs and trends toward smaller families
  - don't penalize for already existing larger family
  - increase poor family's economic status

Empowering women to reduce births

- Women tend to have fewer, and healthier children when:
  - they have access to education and paying jobs outside home
  - their society doesn't suppress women's rights
- But women do most of the work
  - not shown in GDP because of lower pay
  - Women excluded from economic and political decision making

Case Studies - India

- Family planning efforts began in 1952; fertility rate declined from 5.3 to 3.4 but population grow is still exponential -1.9%
- Disappointing results due to:
  - poor planning
  - bureaucratic inefficiency
  - low status of women
  - extreme poverty
  - lack of administrative & financial support

Case Studies - China

- Family planning efforts began in 1970; TFR fell from 5.7 to 1.8; infant mortality and illiteracy rates 1/3 to 1/2 of India's rates
- Population control program is extensive, intrusive and strict:
  - postpone childbearing
  - only one child/family -->benefits
  - effect b/c China is dictatorship; limited resources would have mean disaster

Cutting Global Population Growth

- U. N.Conference on Population and Development, Cairo, 1994
  - 8 goals to be met by 2015 (p. 276)
  - are these goals wishful thinking?
- Replacement level fertility can be met in 15-30 years as shown by Japan, Thailand...
- Invest in family planning, reduce poverty, and elevate status of women

Short of thermonuclear war itself, rampant population growth is the gravest issue the world faces over the decades immediately ahead. If we do not act, the problem will be solved by famine, riots, insurrection and war.

Robert S. McNamara

Impacts of Population Growth

Hunger, disease, economic effects, resources use, habitat destruction