Chapter 8

Human Population: Growth & Distribution

Outline

1. Factors Affecting Human Population Size
   birth & death rates
2. Population Age Structure
   age structure diagrams, developing vs. developed countries, exponential and logistic population models
3. Solutions: Stabilizing Human Population
   computer models, demographic transition
4. Case Studies
   United States, India, China
5. Human Population & Sustainability

Studying Human Populations

- Describe how the size and growth rate for human population has changed over history
- What factors lead to population changes
- Analyze populations using Age Structure Diagrams
- *Terms: Demography, Age Structure, Survivorship, Fertility, Migration, Life Expectancy*

Warm-Up

- What is the world population right now?
  - About 7 billion people
  - Is that too much?
- What is the population of the U.S.?
  - About 313 million people
  - Is that too much?

China's One-Child Policy

- In 1970, the average Chinese woman had about six children.
- Since 1979, China has used a system of rewards and punishments to enforce a one-child limit to slow population growth.
- In 2005, there were 32 million more males than females in China under the age of 20

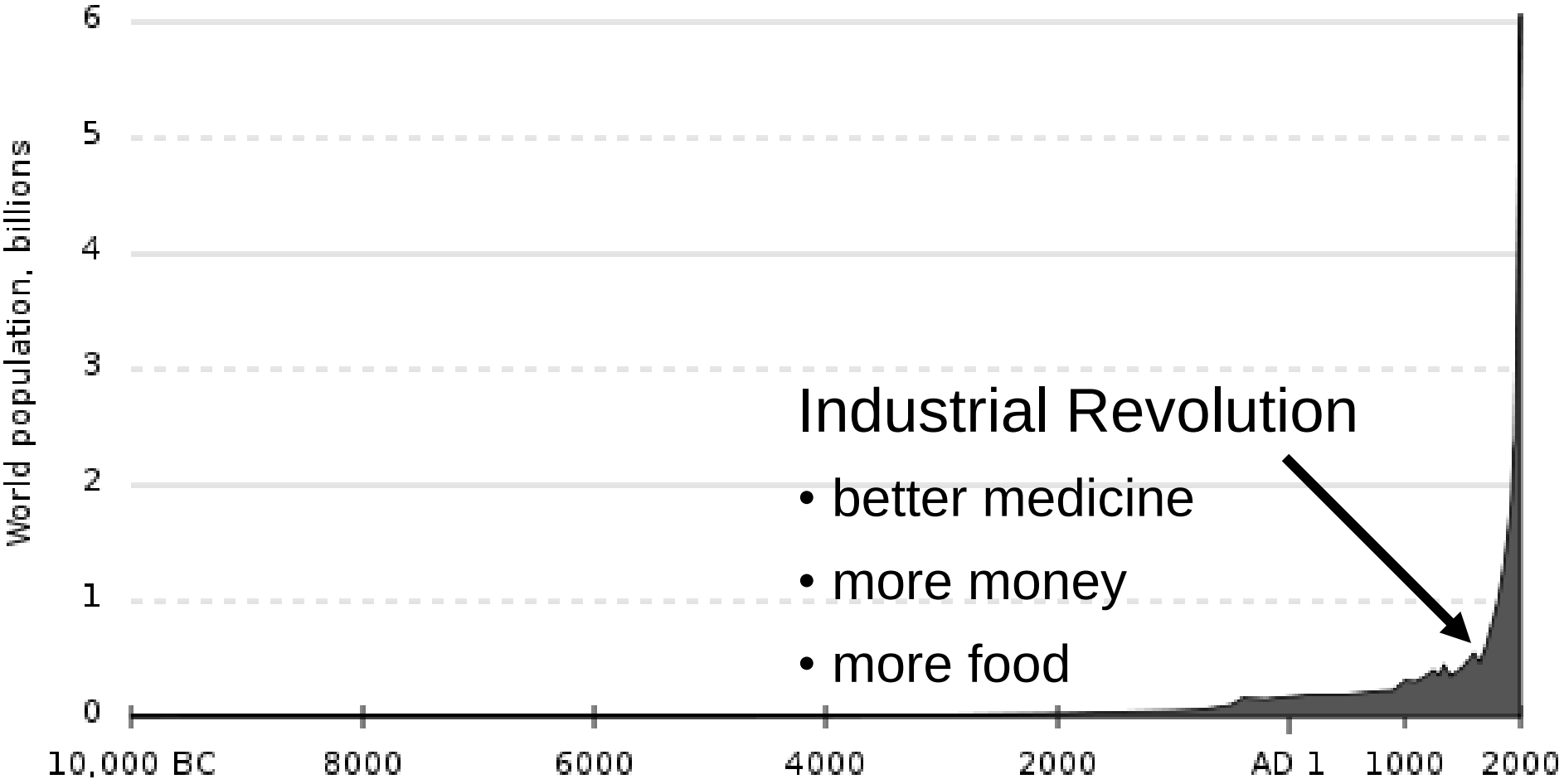
Talk About It Is it ethical for governments to limit or encourage human population growth?

What do you think?

*CENTRAL CASE:

China's "one child" policy has dramatically slowed their country's population growth. *Should other countries (such as the U.S.) follow their example? Should the government be able to tell you how many kids you can have?*

Human Population Growth



What kinds of historical events were taking place in the 1700s and 1800s?

Human Population Growth

Population	Year Reached	Years to Reach
1 billion	1850	
2 billion	1930	
3 billion	1960	
4 billion	1974	
5 billion	1987	
6 billion	1999	

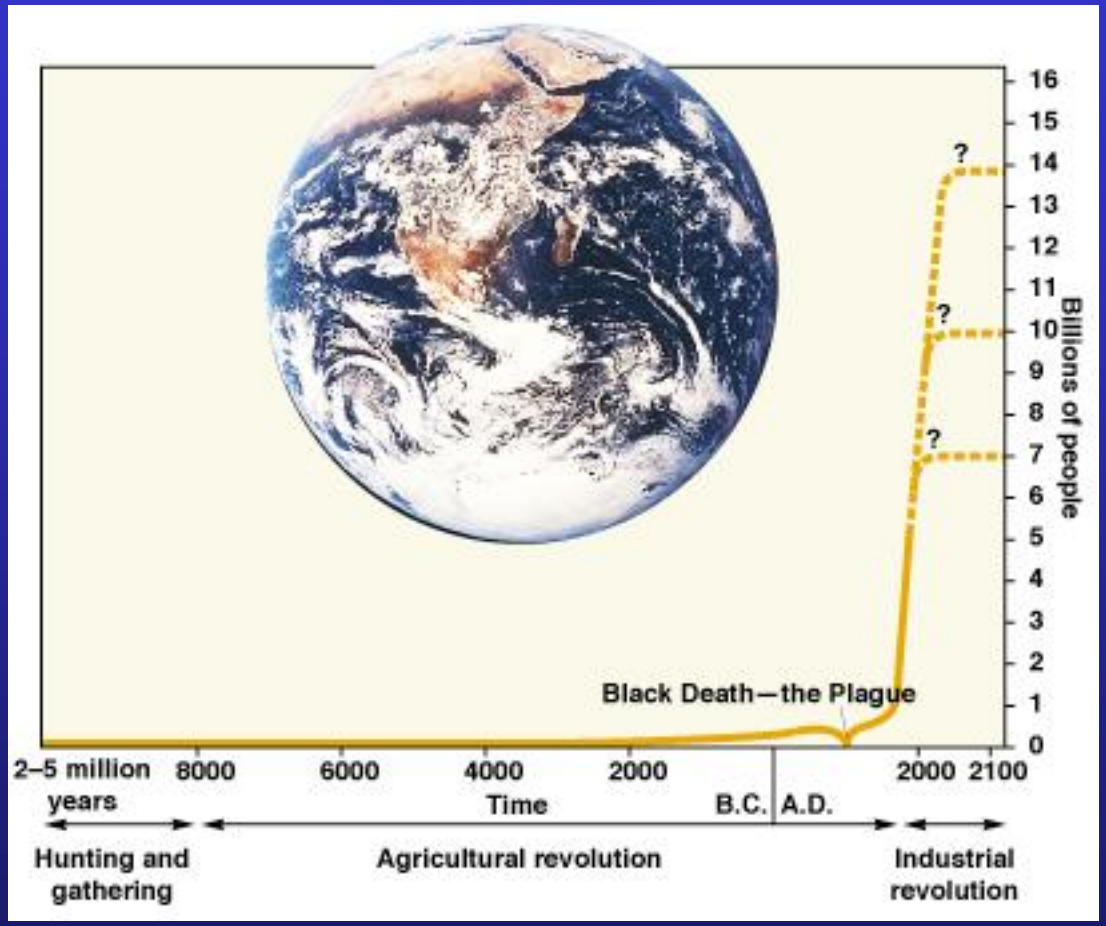
Studying Human Populations

- Demography: the study of human population
- How many people live where?
- How long are you expected to live?
- How many children are you likely to have.

Factors Affecting Human Population Size

Human population is currently growing exponentially:

- What will be the ultimate size of the human population?
- What is Earth's carrying capacity? (How many humans can Earth support?)



What do you think?

- If we cannot provide the basic necessities for 1 billion people today, how will we provide these necessities to an additional 3 billion people in 2050?

Demography

- **Population size:** Number of people
- **Population density:** Number of people living per mi^2 (or per km^2)
- **Population distribution:** How people are distributed within an area

Population Size

- Why care about the size of the population?
- How can scientists estimate the population (say Elephant Seals on a beach in Cali?)

Population Size

- **Population size**-the number of individuals present in a given population at a given time
- Sudden and dramatic decreases in population size can indicate an unhealthy population headed toward extinction
- Can be difficult to measure! ***Why?***

- Example: small populations of immobile organisms (simply count)
- Example: abundant, widespread, and mobile populations cannot be counted (must be estimated)

Mark and Recapture

- Common way of estimating population size

Population Size Continued…

- MUST assume that the ***distribution of individuals in the entire population is the same as that in the sampled group***
- ALL estimates with the ***potential for error!***

Population Size Continued…

- Sometimes it's easier to find signs of organisms to count
  - ***Ex: rare organisms, hidden organisms***
- Can count animal tracks or droppings

Population Density

- **Population density**-measures how crowded a population is
- Expressed as the number of individuals per unit area

- Ex: 1500 gold toads in 1987 found w/in a 4 sq. km → density= 1500 toads/4 sq. km
- Estimates calculated for the total land area

Population Density

- Larger organisms (lions) → lower population density
- Why?

- Larger= more space

Different Densities

High Population Density:

- Pro →
  - 1. Easier to group together & find mates
- Con →
  - 1. increased competition
  - 2. organisms more vulnerable to predation
  - 3. increased transmission of disease

Low Population Density:

- Pro →
  - 1. Organisms have more space and resources available
- Con →
  - 1. Harder to find mates/companions

*REFLECT ON HW ARTICLE

“Greenest Place in the U.S.?
It’s Not Where You Think”
-David Owen

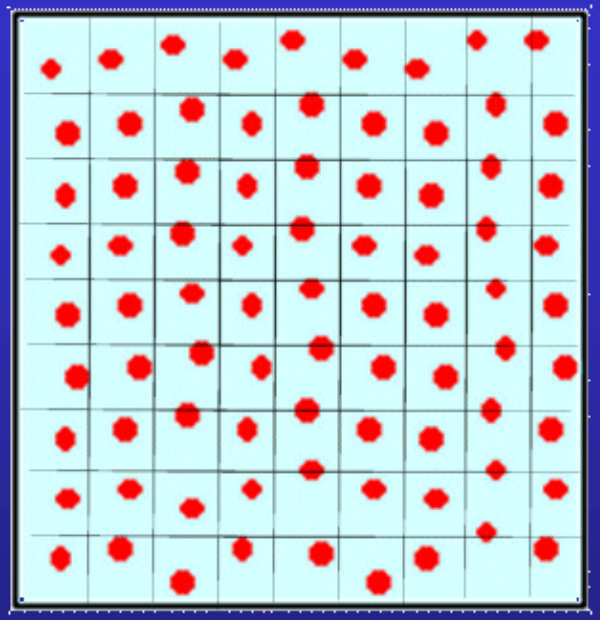
Population Distribution
aka: Population Dispersion

- **Distribution** is how organisms are arranged within an area

- Include clumped, uniform, and random distributions

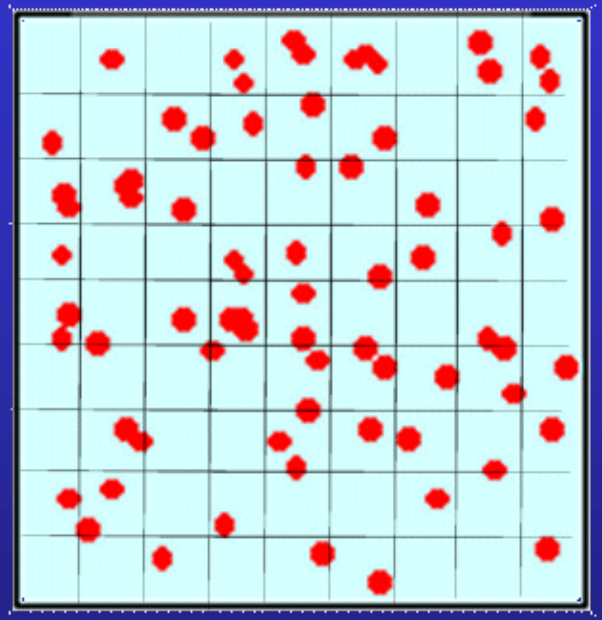
Population Distribution

How organisms are arranged within an area:



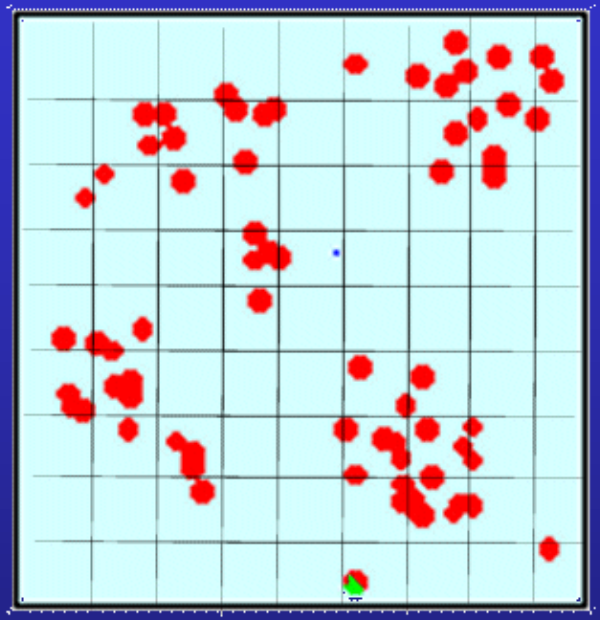
UNIFORM

Occurs when individuals hold territory or compete for space. Plants in desert



RANDOM

Occurs where resources needed are found throughout, wildflowers in meadow



CLUMPED

Most Common. Occurs where resources are together. Water hole in desert, humans in cities, herds/flocks

Many bird species are territorial. In territorial birds species, what kind of population structure would you expect?

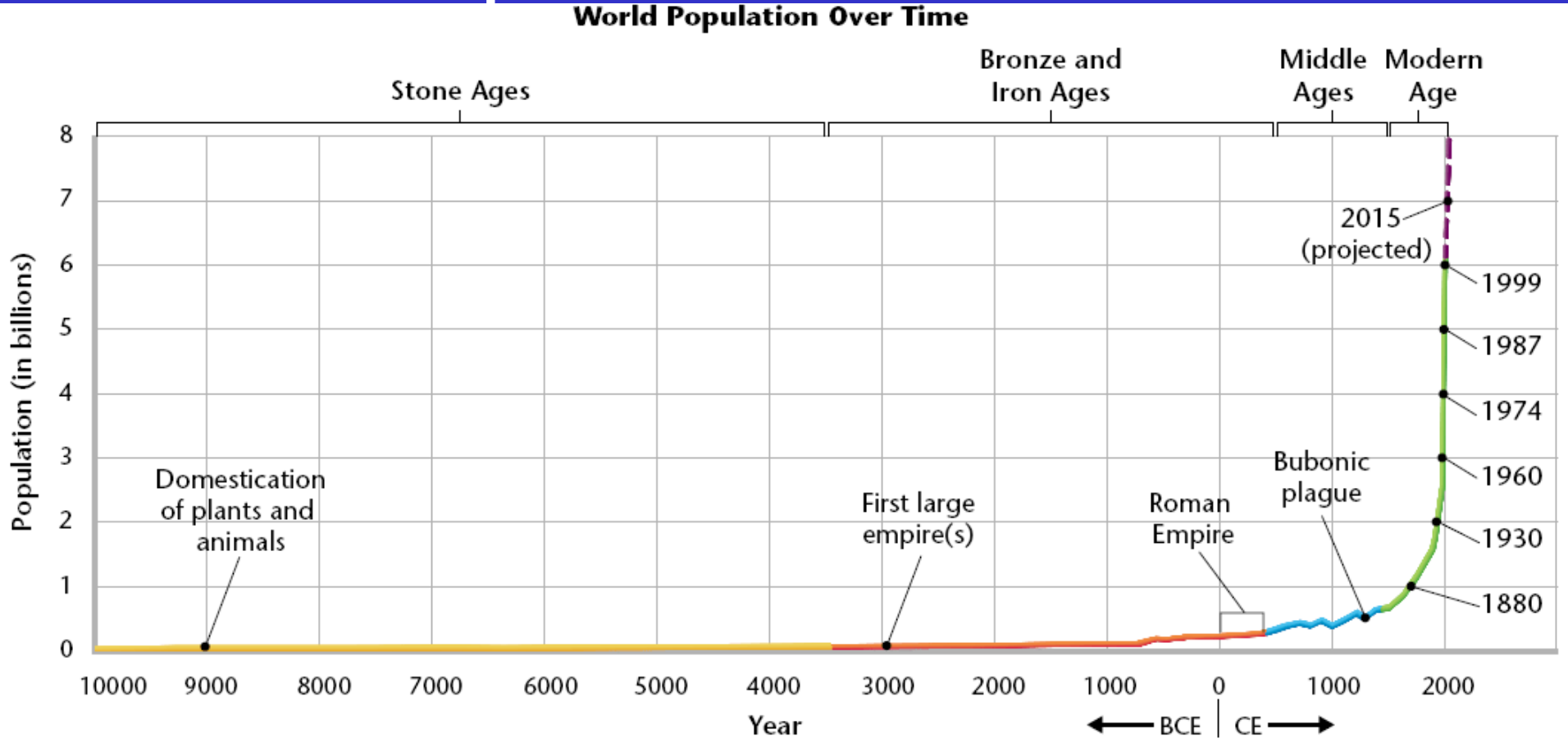
UNIFORM

What type of distribution?

CLUMPED

WHY?

Exponential Growth



- Exponential Growth: rapid growth often seen as J-Shaped curve on a graph – BR higher than DR
- Can that growth continue?

Application of Exponential Model

- Ex: bacteria can grow exponentially if provided by abundant food & space (if wastes are removed)
- Exponential model does NOT apply to most populations
- Populations do NOT grow indefinitely
  - WHY???

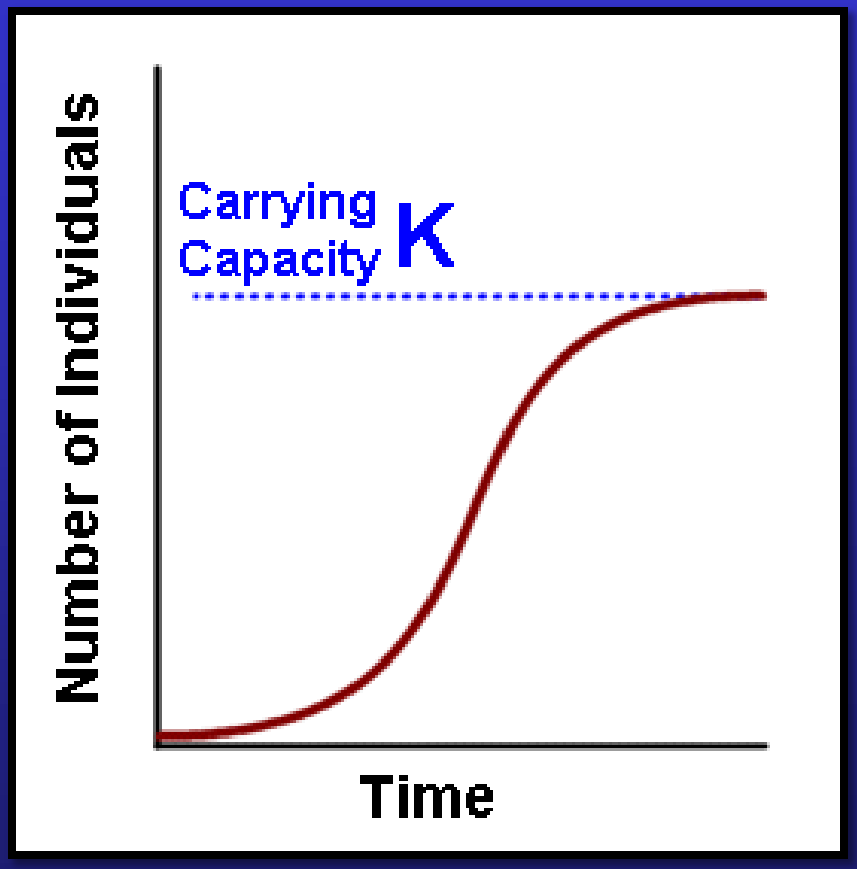
Application of Exponential Model

- Limiting Factors → space, food, etc.
  - Any factor that restrains growth of population

- Environmental resistance → sum of limiting factors

Logistic Model

- Accounts for influence of limiting factors
- Carrying capacity (K) = # of individuals that environment can support over a long period of time
- Stretched letter “S”



What happens when populations exceed “K?”

- Something gives!
- Food shortages, habitat destruction, starvation, density dependent diseases
- POPULATION CRASHES!

- Environmental degradation = population uses up resources faster than they can be replenished

Population Controls

- ***Density dependent*** → depend on number of individuals in the same area – triggered by increasing population density
  - Shortages of food/nesting site
- ***Density independent*** → reduces the population by the same proportion, <u>regardless of the population size</u>
  - Weather, flood, fire

Forecasting Population Size

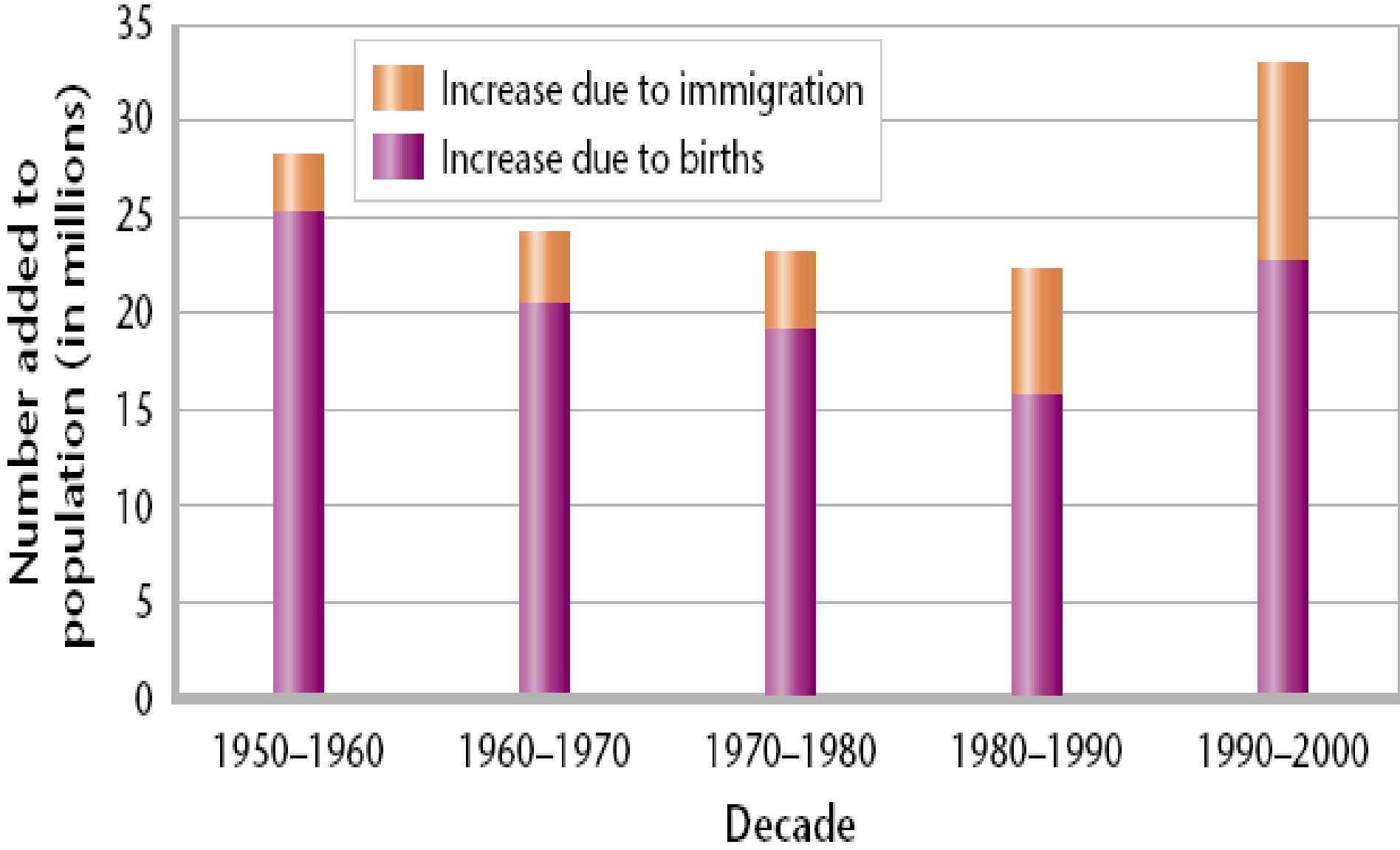
- Will new schools be needed?
- Should we be building more housing?
- Should farming practices be improved?
- Predictions like this often wrong because human behavior changes

Factors Affecting Human Population Size

Population change is calculated as the difference between individuals entering and leaving a population:

Population Change = –

- **Birth Rate** – the number of births per thousand people
- **Immigration** – moving into a country
- **Death Rate** – the number of deaths per thousand people
- **Emigration** – moving out of a country
- **Zero Population Growth** (ZPG) occurs when factors that increase and decrease population size equal each other


Number added to population (in millions)
35
30
25
20
15
10
5
0
Increase due to immigration
Increase due to births
1950–1960
1960–1970
1970–1980
1980–1990
1990–2000
Decade

•Population

•Change = •(births + immigration) – (deaths + emigration)

- Death rates on the decline… people living longer
- Why?

  •Better hygiene, sewage disposal, clean water, medicines, education, access to food, nutrition

Population Calculations

Net population Change =
(births + immigration) – (deaths + emigration)

There are 300 people living in a village, 50 children are born, 20 people die, 10 immigrate and 2 emigrate. What is the new population?

Population Calculations

Growth rate=

$$\frac{(\text{current})\ BR_{(+\ \text{immigr})} - (\text{current})\ DR_{(+\ \text{emigr})}}{10}$$

If there were 20 people born per 1,000 people and 8 deaths per 1,000 peoples, the global population growth rate would be 1.2%

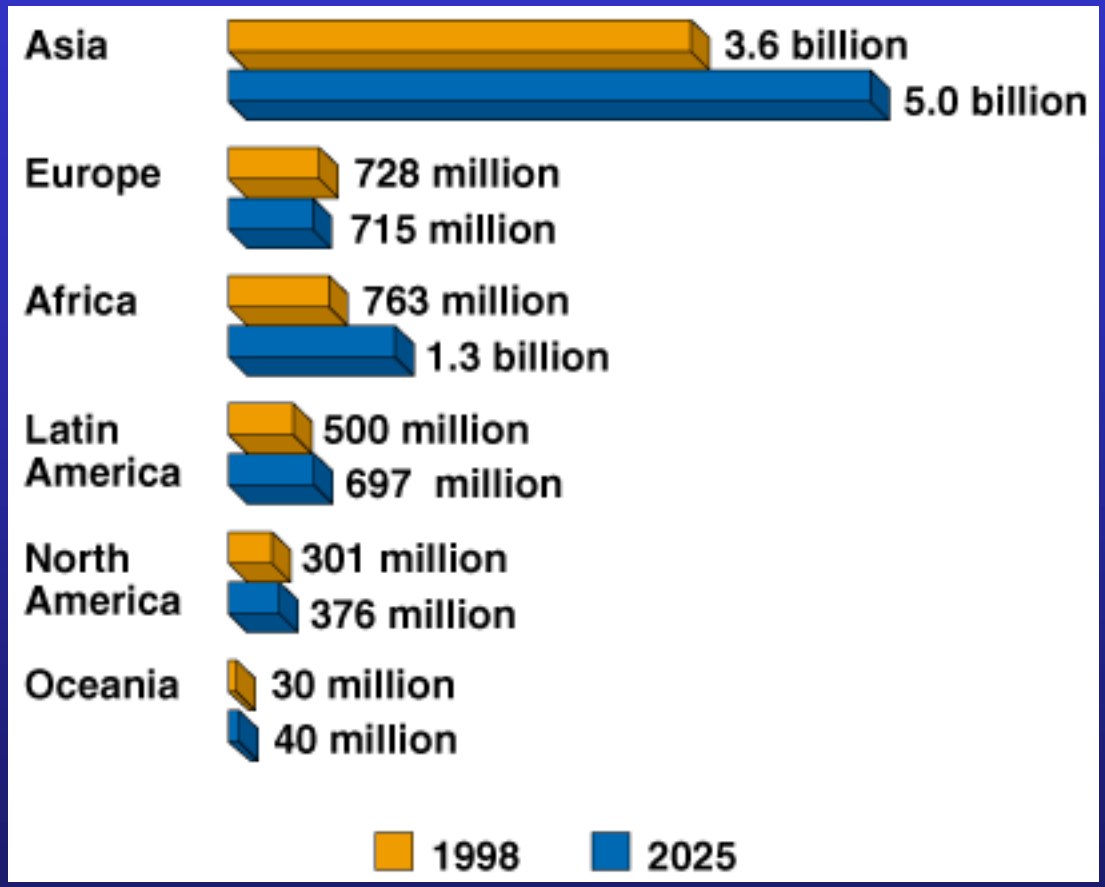
- $\frac{20 - 8}{10}$

Population Size by Continent

Population size by region in 1998, with projections of population size in 2025.

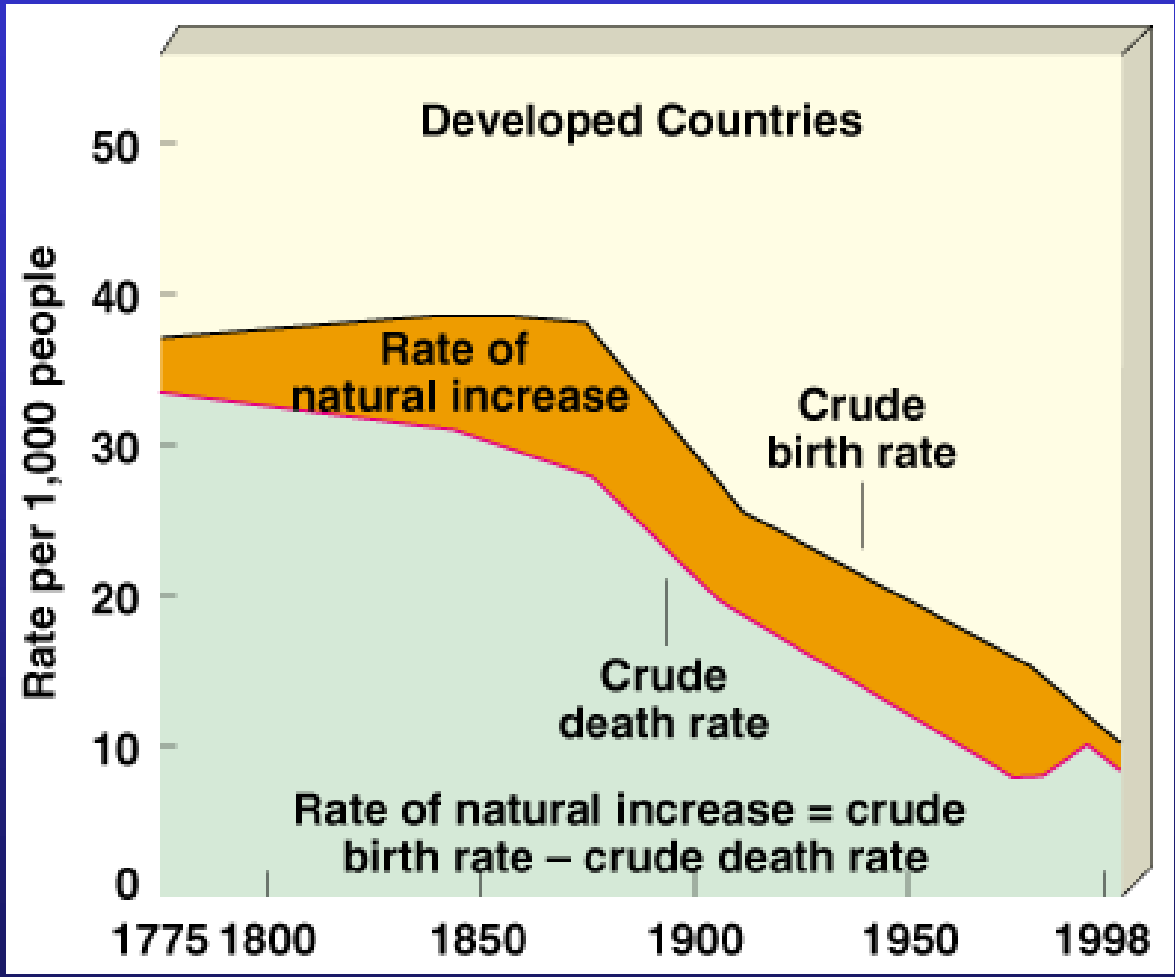
There are about 84 million births each year.

% of new births are in developing countries



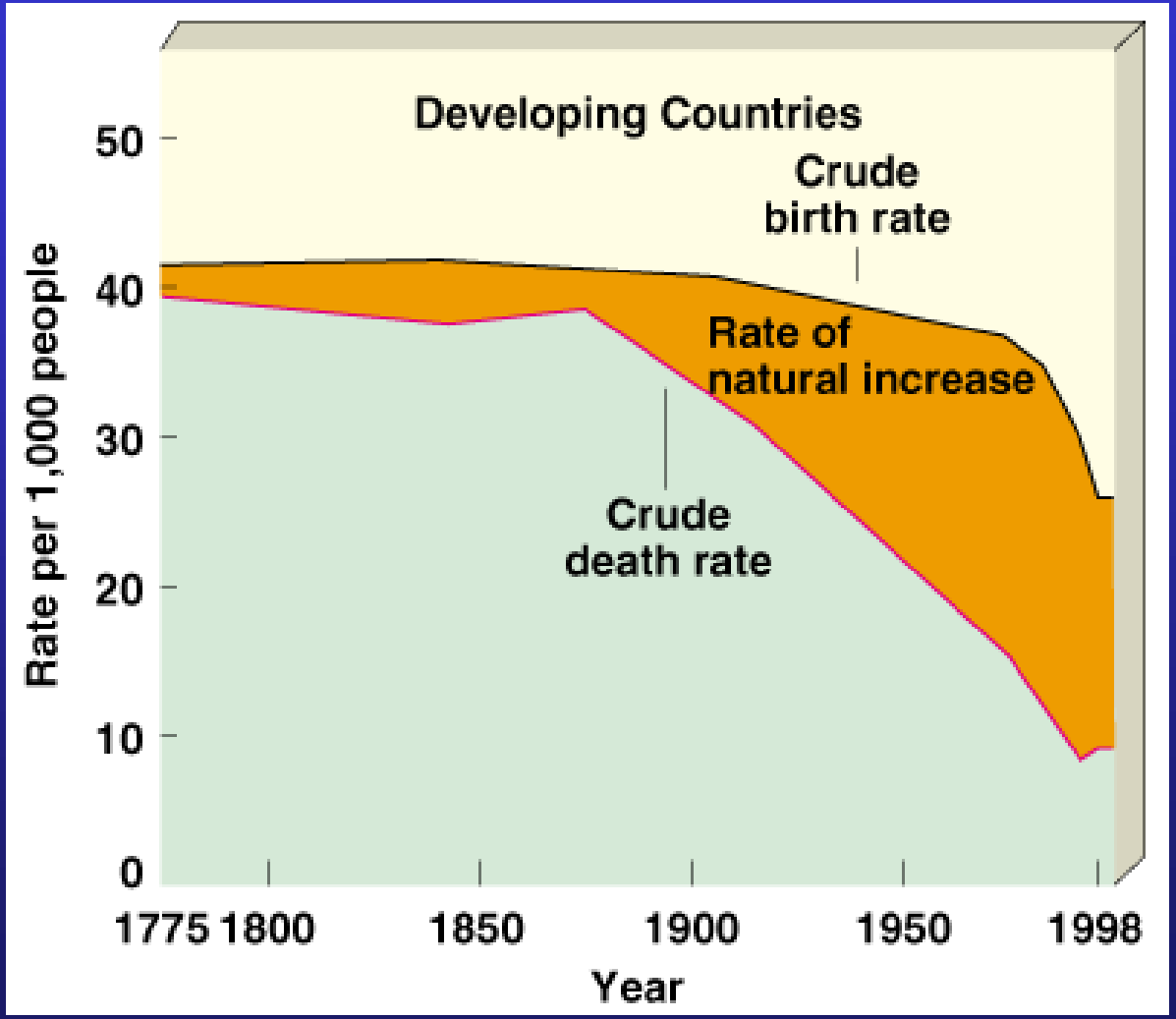
Birth & Death Rates Over Time

*In **developed countries**, decreases in death rates are being accompanied by decreases in birth rates over time.*



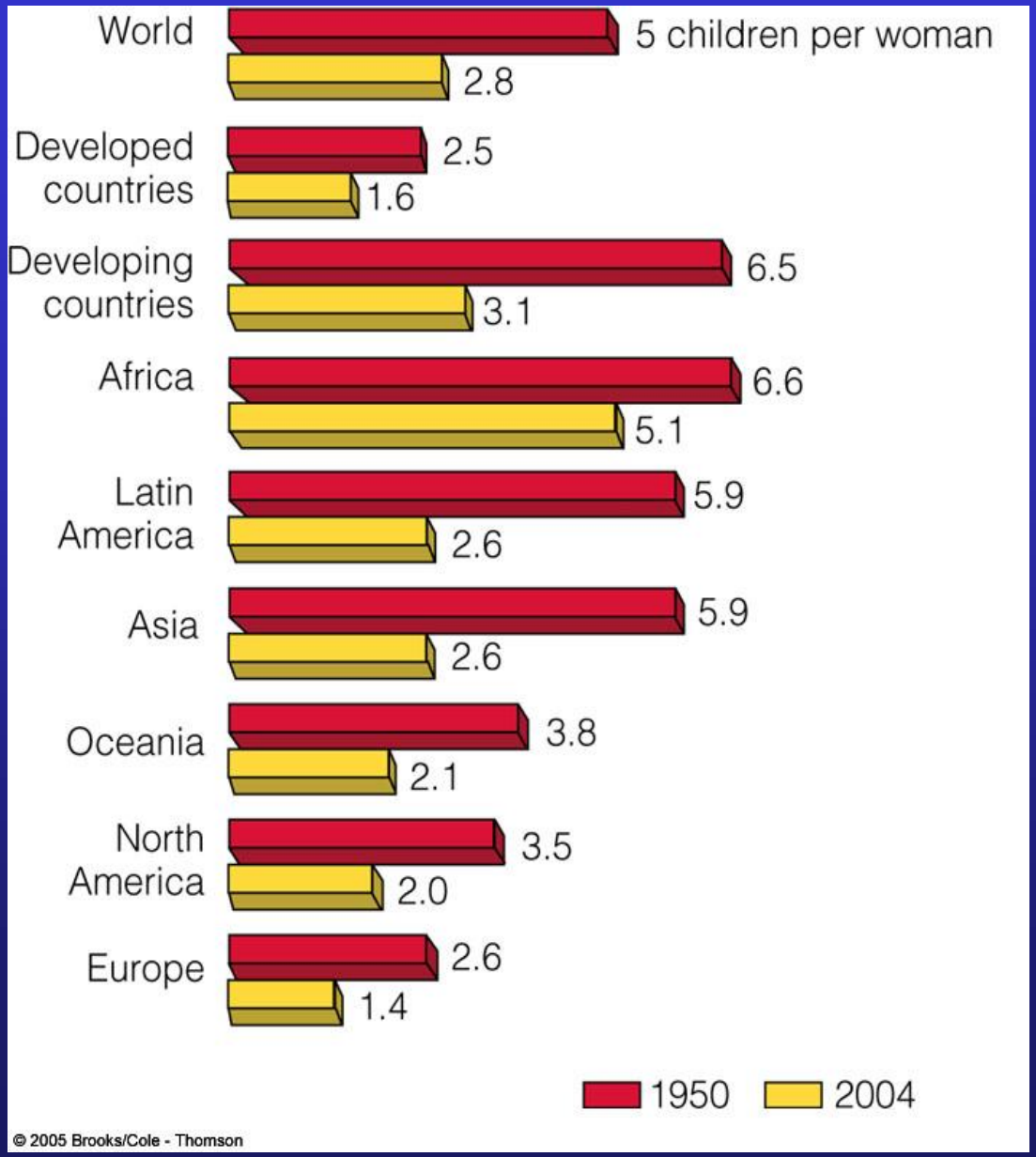
Birth & Death Rates Over Time

*In **developing countries**, decreases in death rates have not been accompanied by as large of decreases in birth rates over time, leading to major population increase.*



Fertility Rates

- Fertility Rates: number of babies born each year per 1,000 women
- Total fertility rate
- Replacement fertility rate



Population Fertility Rates

- ***Replacement Fertility*** *- Number of children needed to replace the parents*

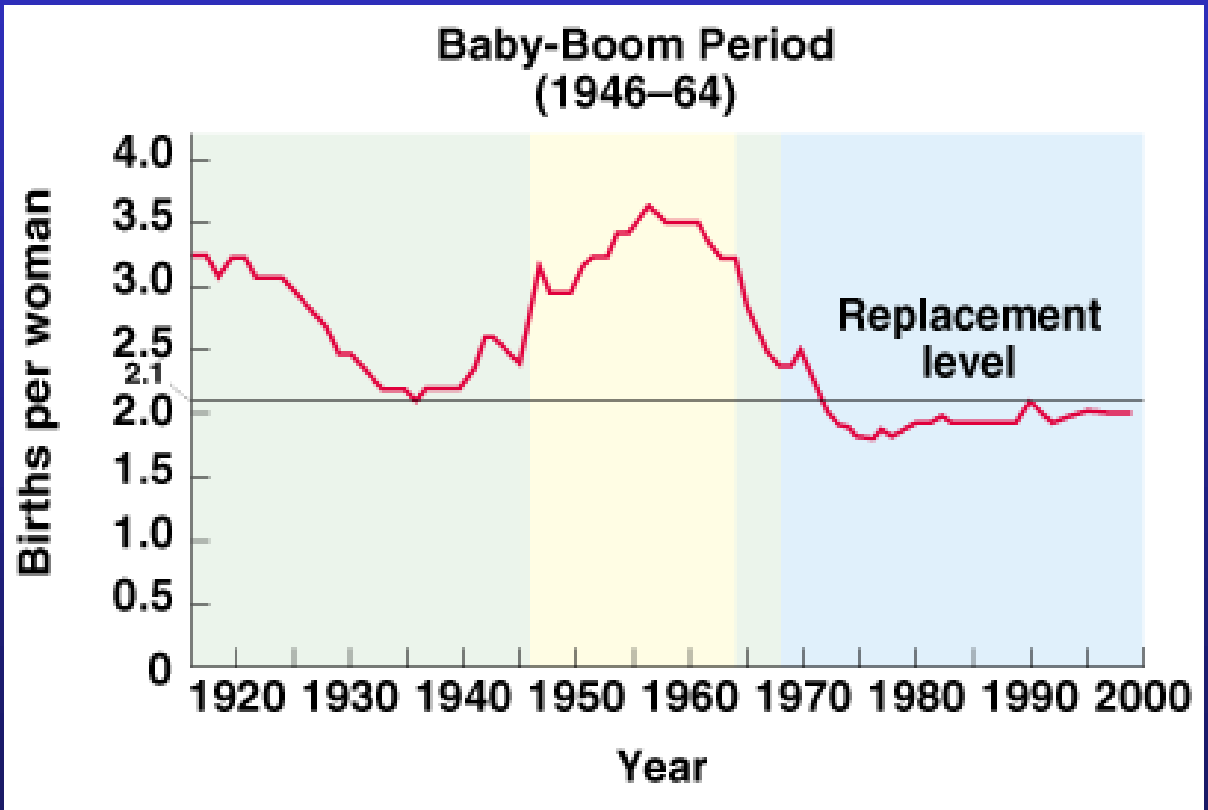
  (2.1 in developed countries, 2.5 in developing countries)

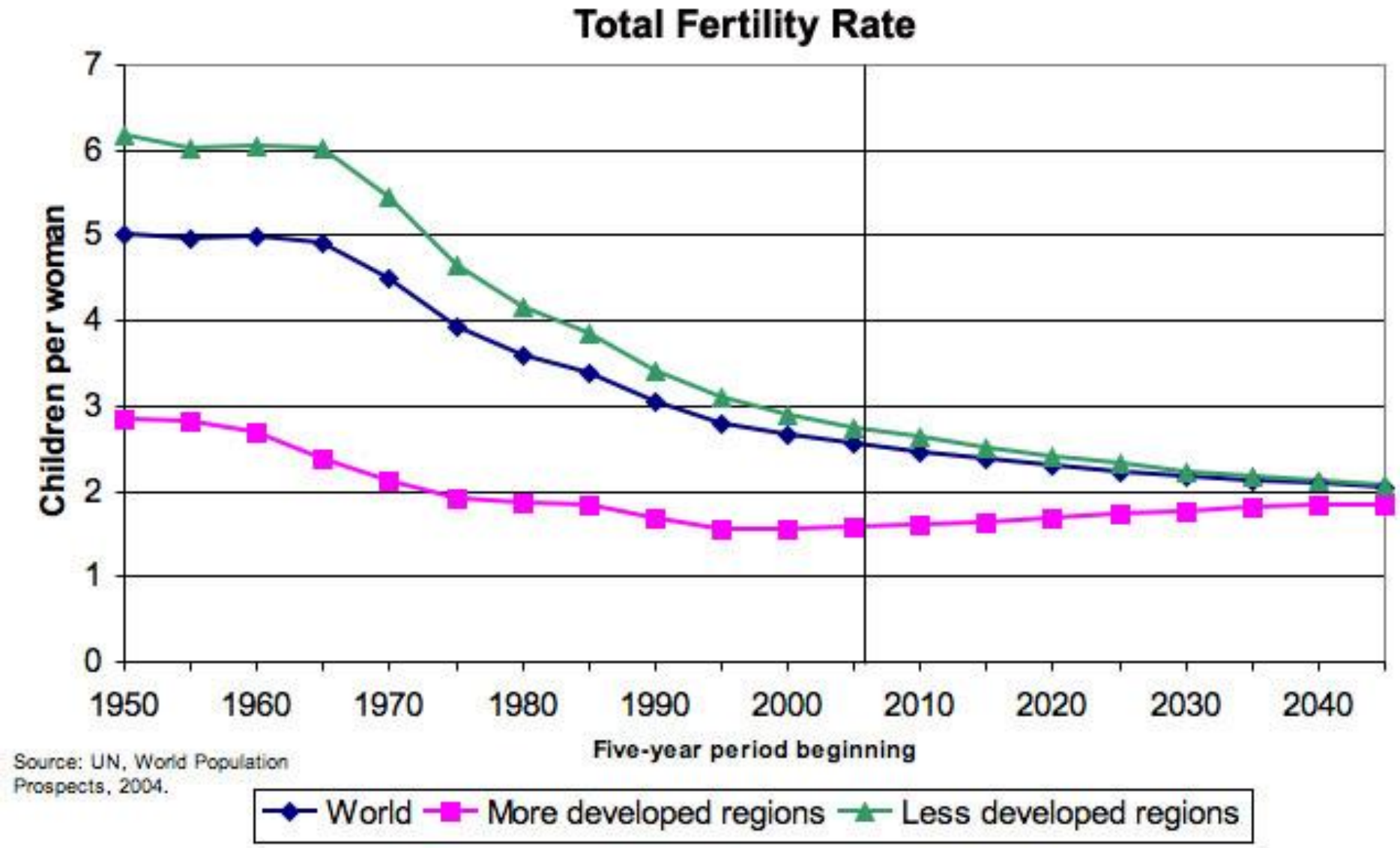
- ***Total Fertility Rate (TFR)*** *- Average number of children each woman has in a population*

  - **Average TFR (births per woman)**
    - *2.8 – Low Income Countries*
    - *2.4 – Middle Income Countries*
    - *1.7 – High Income Countries*

Total Fertility in the United States

Total fertility in the United States had a major increase during the "baby boom" (1946–1964) & is now hovering just below replacement level.




Total Fertility Rate
Children per woman
7
6
5
4
3
2
1
0
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
Five-year period beginning
Source: UN, World Population Prospects, 2004.
World
More developed regions
Less developed regions

Recap: TFR, RF

- https://www.youtube.com/watch?v=zBS6f-JVvTY

Factors Affecting Fertility Rates

What factors decrease human fertility levels?

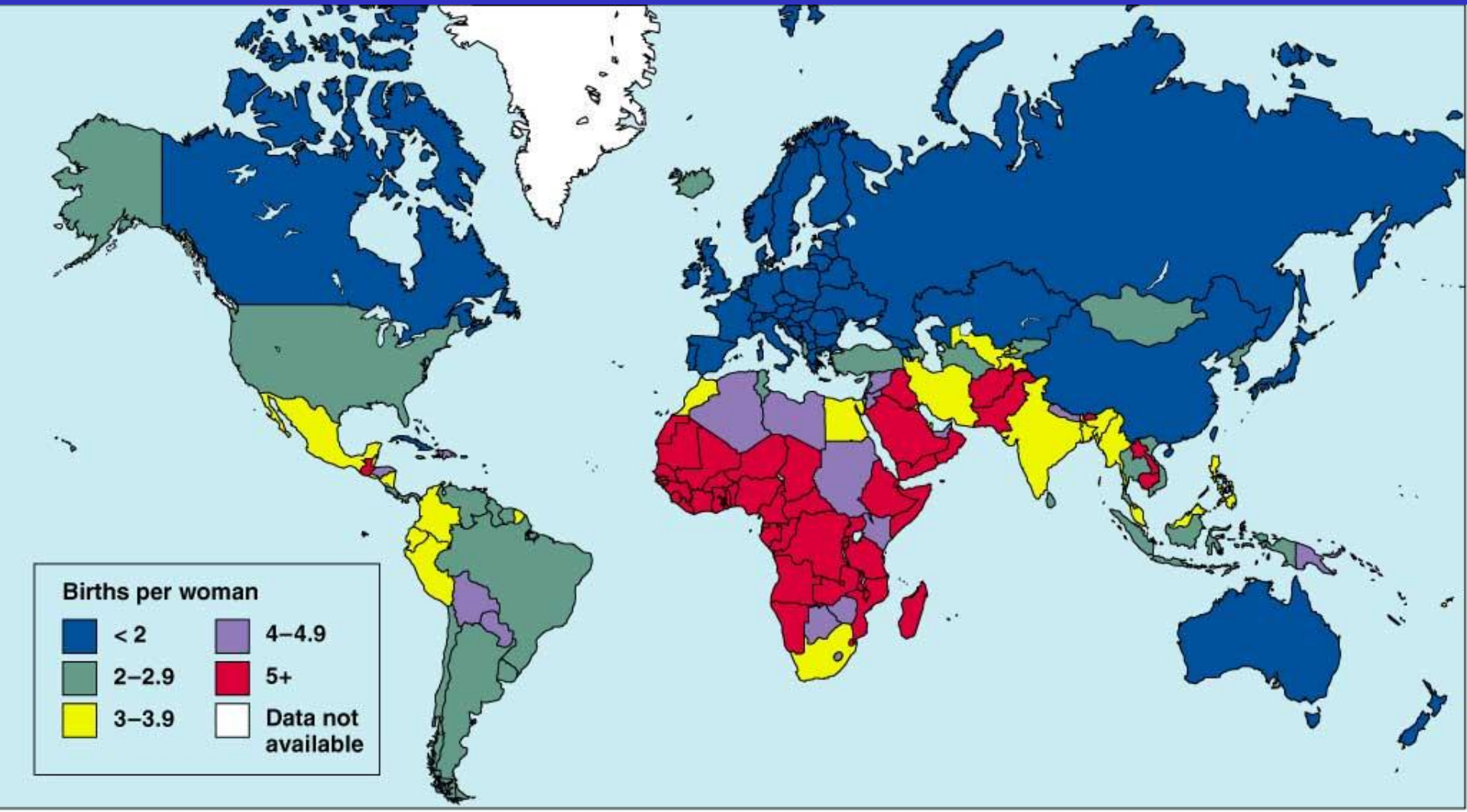
(What causes people to have fewer children?)

Factors Affecting Fertility Rates

The following are significant factors that decrease human fertility levels:

- increase in average level of education/knowledge of family planning & affluence
- decrease in importance of child labor
- increased urbanization
- increased cost of raising & educating children
- increased educational & employment opportunities for women
- decreased infant mortality
- higher average age of marriage
- greater availability of reliable birth control
- greater availability of legal abortions
- change in religious beliefs, traditions, & cultural norms away from encouraging large families

TFR (births per woman)



Biotic Potential

- **Rate at which a population would grow if every new individual survived to adulthood and reproduced at its maximum capacity**
  - reaches reproductive age and reproduces
  - no limiting factors such as death, emigration, disease
  - nothing to stop population from growing!

(Continued: biotic potential)

- **Biotic Potential** =maximum ability to produce offspring in ideal conditions
- Factors influencing biotic potential → gestation, generation time

- Gestation = how long it takes for an embryo/fetus to develop and be born (ex:humans – 9 months)
- Generation time = span from an organism's birth to the time it has its own offspring

Scorpion fish vs. Orangutans

- Females mature @ 3-5 y/o
- Release 50,000-100,000 eggs/year
- Eggs take 12-16 days to hatch

- High biotic potential
- *recover more quickly from declines

- Females mature @ 10 y/o
- Give birth to single baby/8 years

- Low biotic potential

Teen Pregnancy

- Which industrialized country has the highest teenage pregnancy rate?

  The United States

- How many American teenage girls become pregnant each year?

  733,000 (girls 15-19 years old)

  13,500 (girls 14 and younger)

Teen Pregnancy

- What is the pregnancy rate for American girls ages 15-19?

  67.8 per 1,000 girls (~7%)

- Is the teen pregnancy rate increasing or decreasing?

  It has decreased 42% since 1990 peak

Indicators of Health

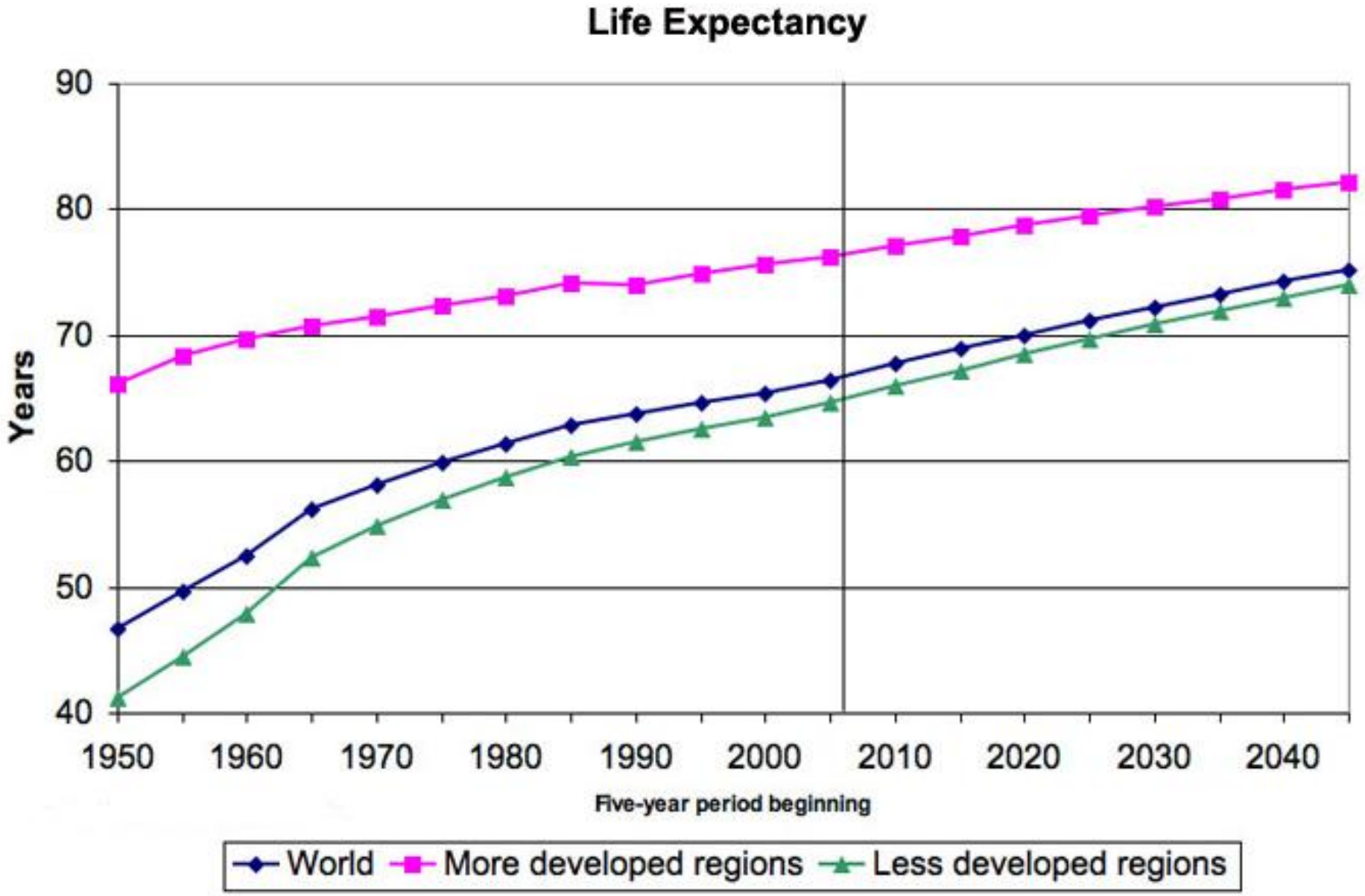
"It's not as if people suddenly started breeding like rabbits; it's just that they stopped dying like flies." Peter Adamson

Life expectancy *- The number of years a newborn can expect to live*

Low Income Countries -

Middle Income Countries -

Upper income Countries -


Life Expectancy
90
80
70
60
50
40
Years
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
Five-year period beginning
World
More developed regions
Less developed regions

Indicators of Health

"It's not as if people suddenly started breeding like rabbits; it's just that they stopped dying like flies." Peter Adamson

Infant mortality *- Number of babies out of every 1,000 that die within a year of birth*

Angola –

India –

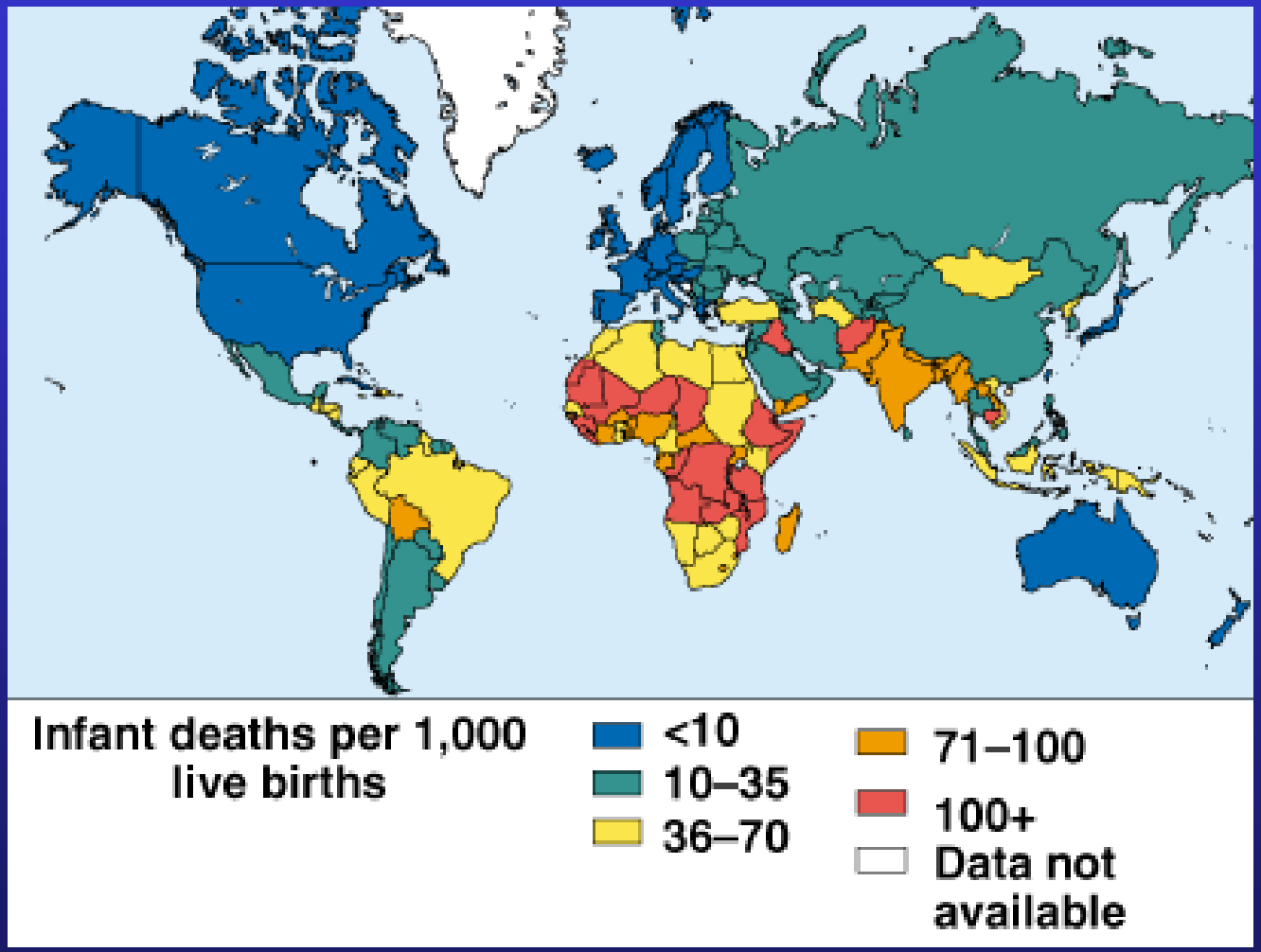
United States –

Singapore –

World Average –

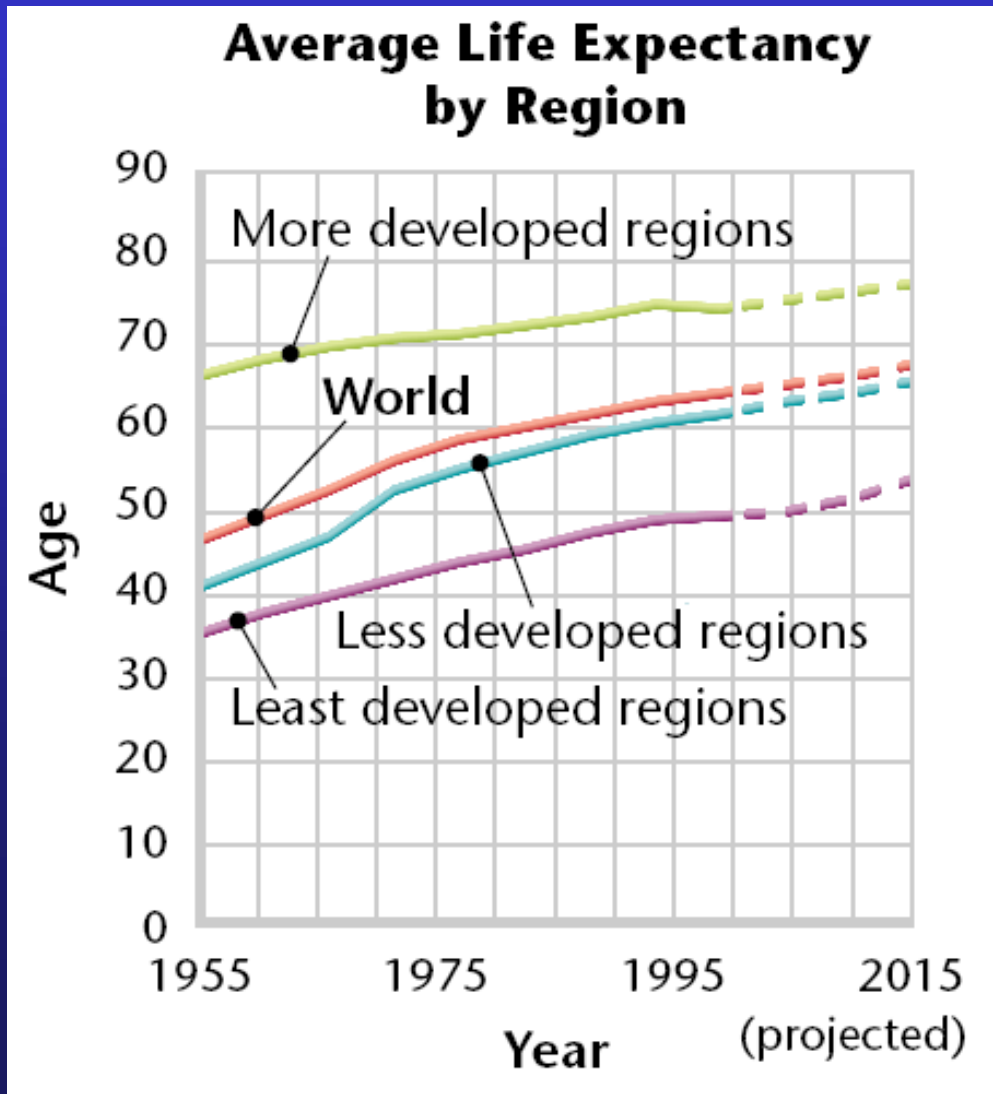
Death Rates

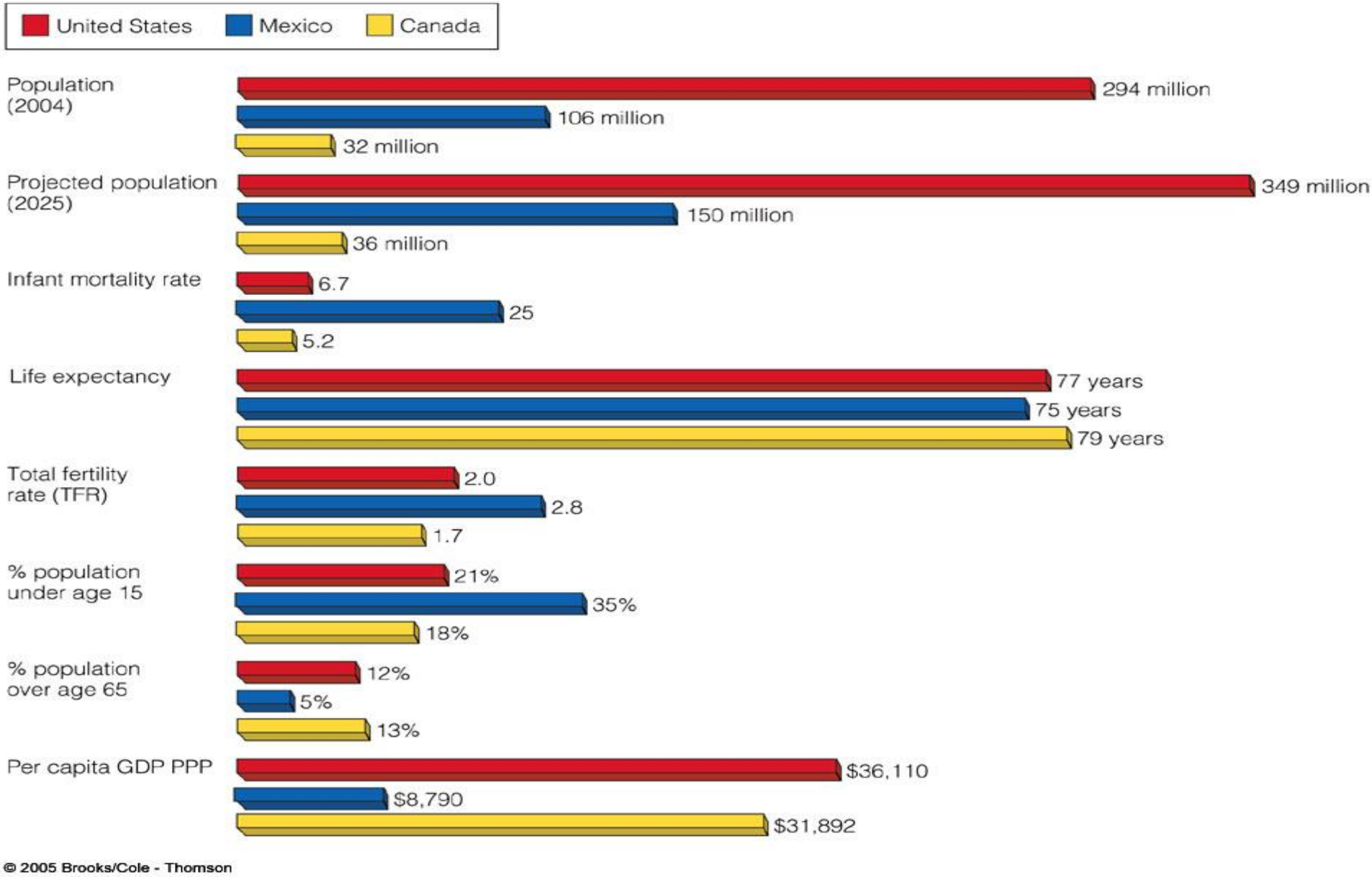
Infant death rates are lower in developed countries than developing countries



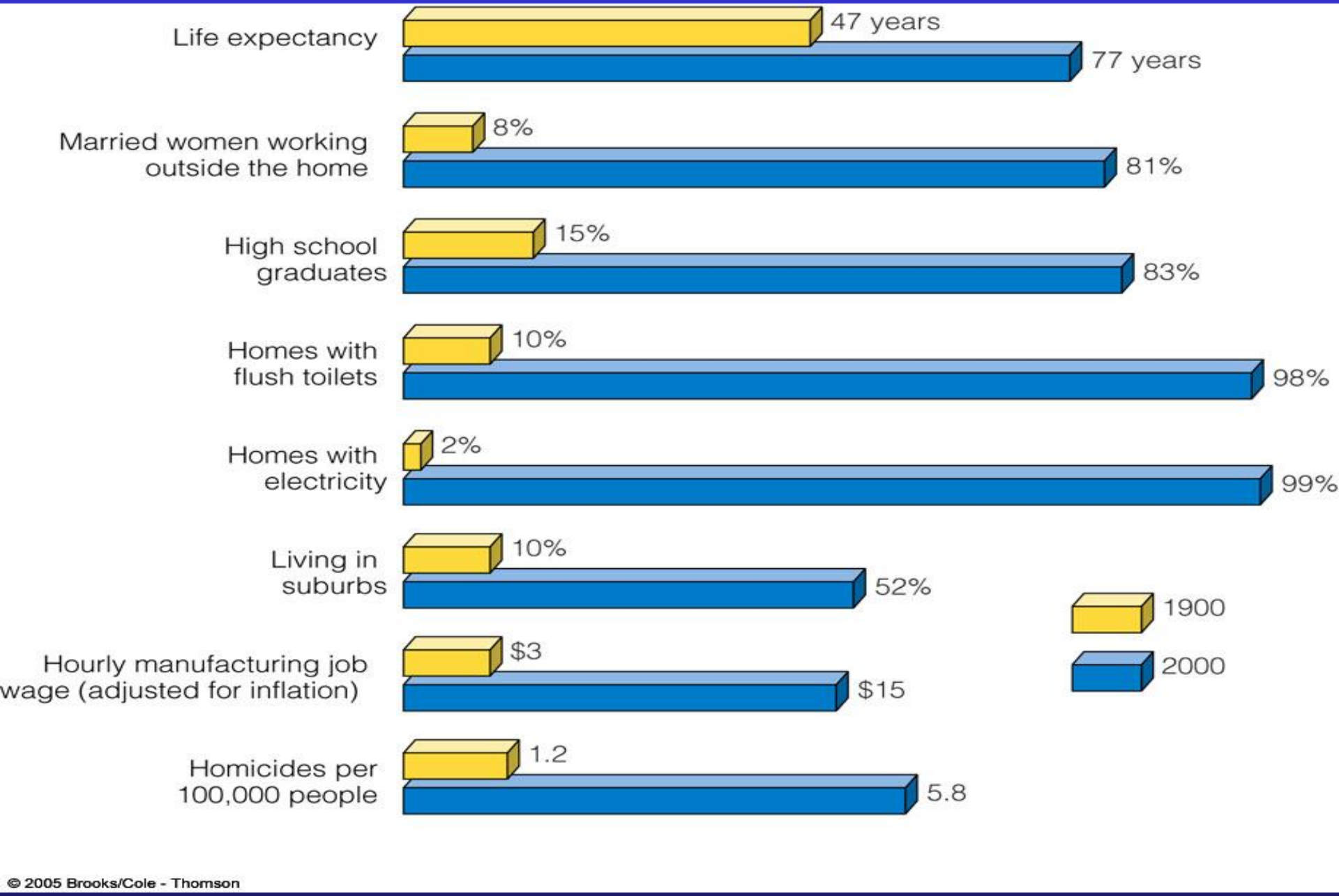
Life Expectancy

- Life Expectancy: average number of years members of a population are expected to live
- Improvement in most of world
- Lower INFANT MORTALITY





- Compared to our neighbors



- Major changes in U.S. over last 100+ years

Doubling Time

- **Number of years needed to double a population, assuming a constant rate of natural increase**
- Most countries double their population in less than 25 years while others have z.p.g (BR equal DR, so no growth)
- The larger the difference between a nation's BR & DR → the greater the increase in population growth

Doubling Time

- **% natural increase = $\frac{\text{BR – DR}}{10}$**
- Doubling time = $\frac{70}{\text{rate of increase}}$
- 70 → "magic number" – equivalent of 100 times for natural log of 2

Rule of 70: Doubling Time

- If we know the growth rate of a population and assume that growth rate is constant, we can calculate the number of years it takes for a population to double. **Rule-of-70 - way to calculate the approximate number of years it takes for the level of a population growing at a constant rate to double.**

- States that the approximate number of years *n* for a variable growing at the constant growth rate of *r* percent, to double is:

$$n = 70/r$$

Rule of 70: Doubling Time

- For example, a city with an annual population growth rate of 5% will double its population in approximately 14 years. $\frac{70}{5} = 14$
- If the growth rate were 7%, it would double its population in approximately ? years.

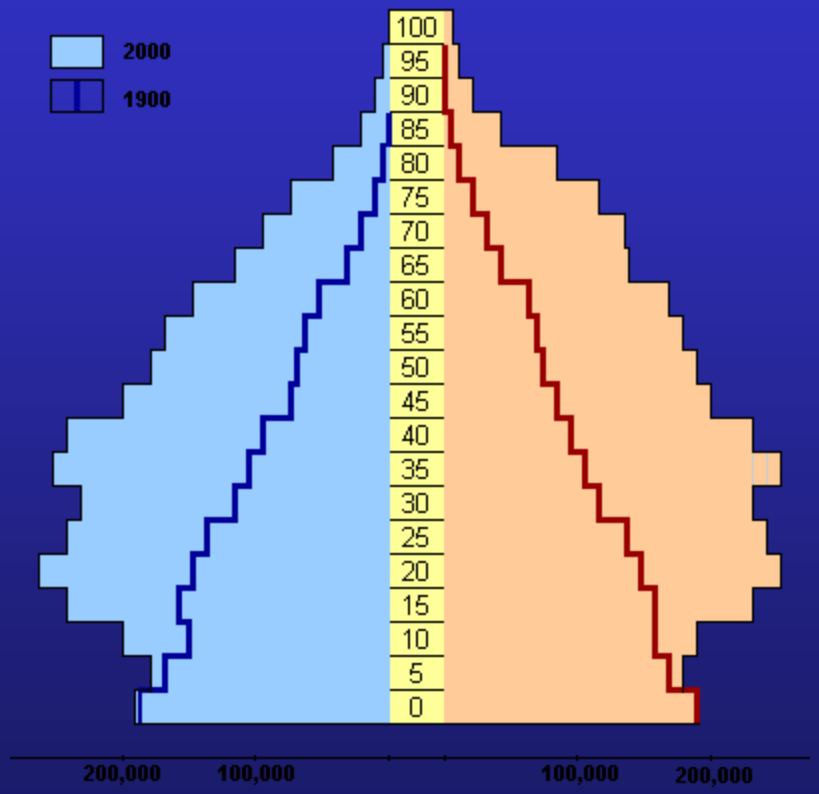
Rule of 70: Doubling Time

- Remember that a population growing at 2 percent per year, regardless of the size will double in 35 years. Whether the population is 500,000 or 50,000, it will still double in the same amount of time.

- It is almost certain that the Earth's population will not double again. Most demographers believe that the human population will be somewhere between 8.1 billion and 9.6 billion in 2050 and stabilize by 2100.

Forecasting Population Size

- Age Structure: the distribution of ages in a population
- Age Structure Diagrams aka population pyramids
- What is useful about these diagrams?

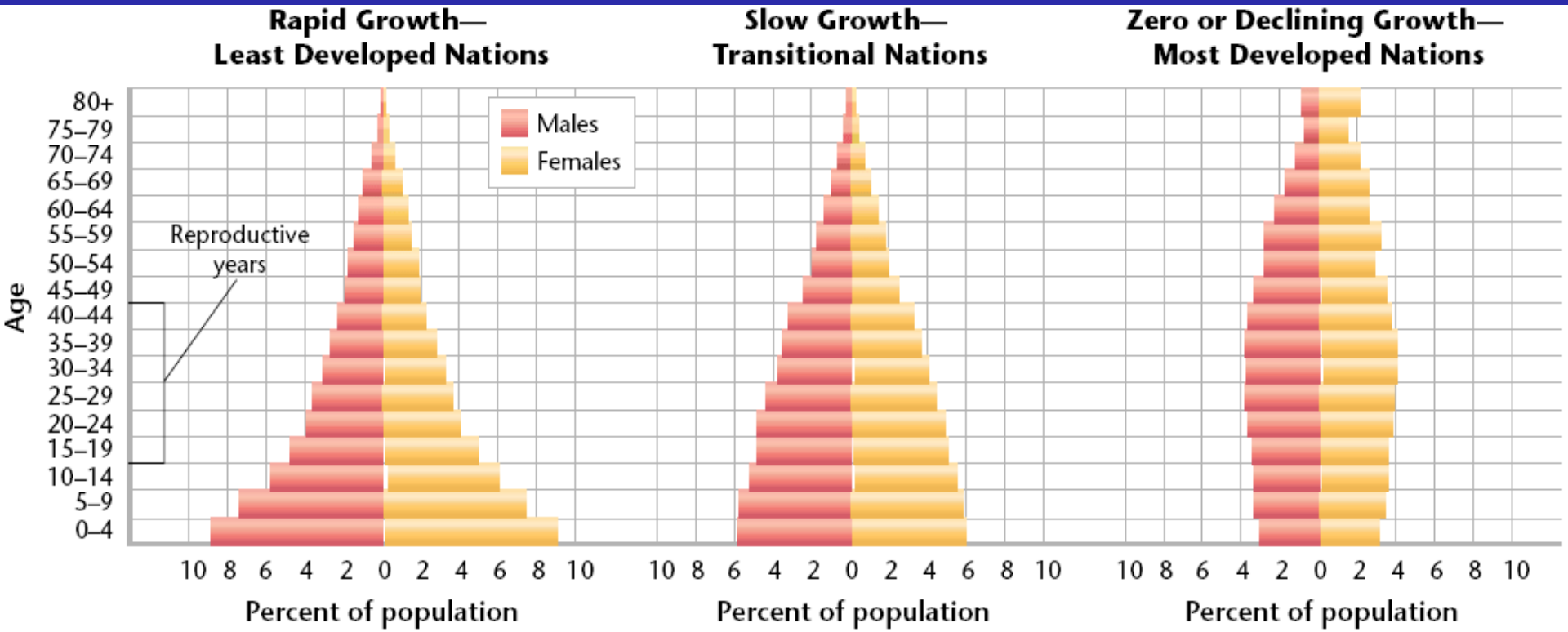


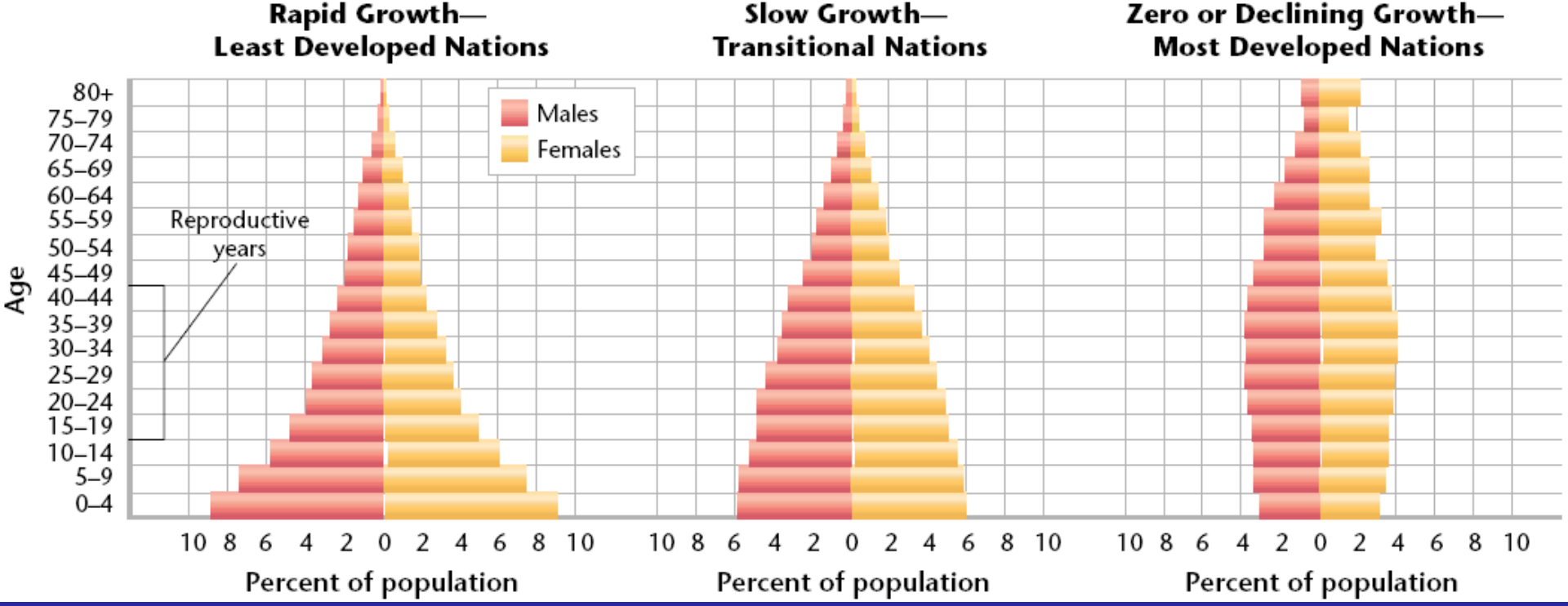
Population Age Structure

Age structure *refers to the proportion of the population in each age class:*

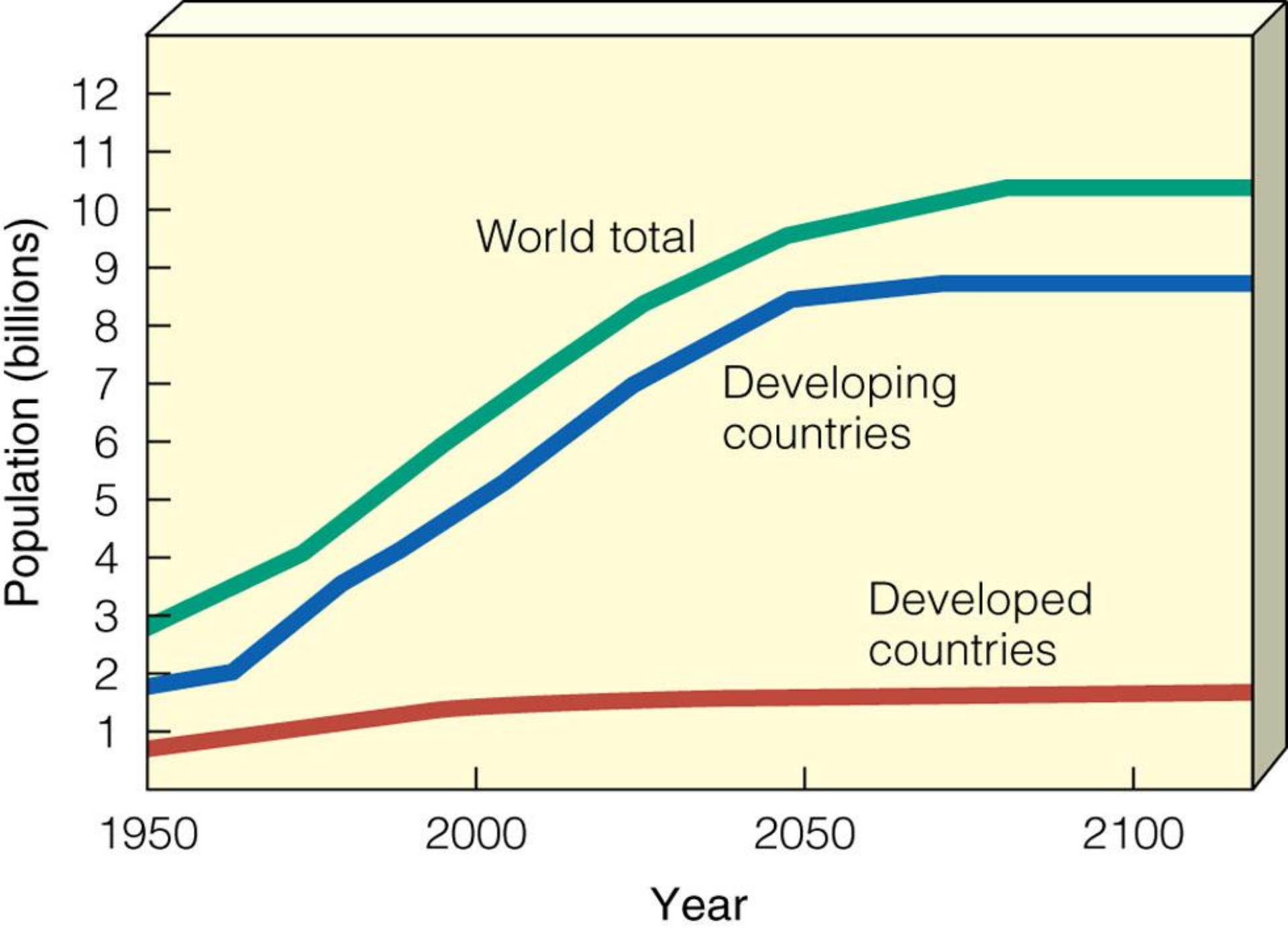
- Pre-reproductive (0–14 years)
- Reproductive (15–44 years)
- Post-reproductive (45 & up)

- What are these age-structure diagrams showing?
- What are the “reproductive years” Why is that important in forecasting future population growth?





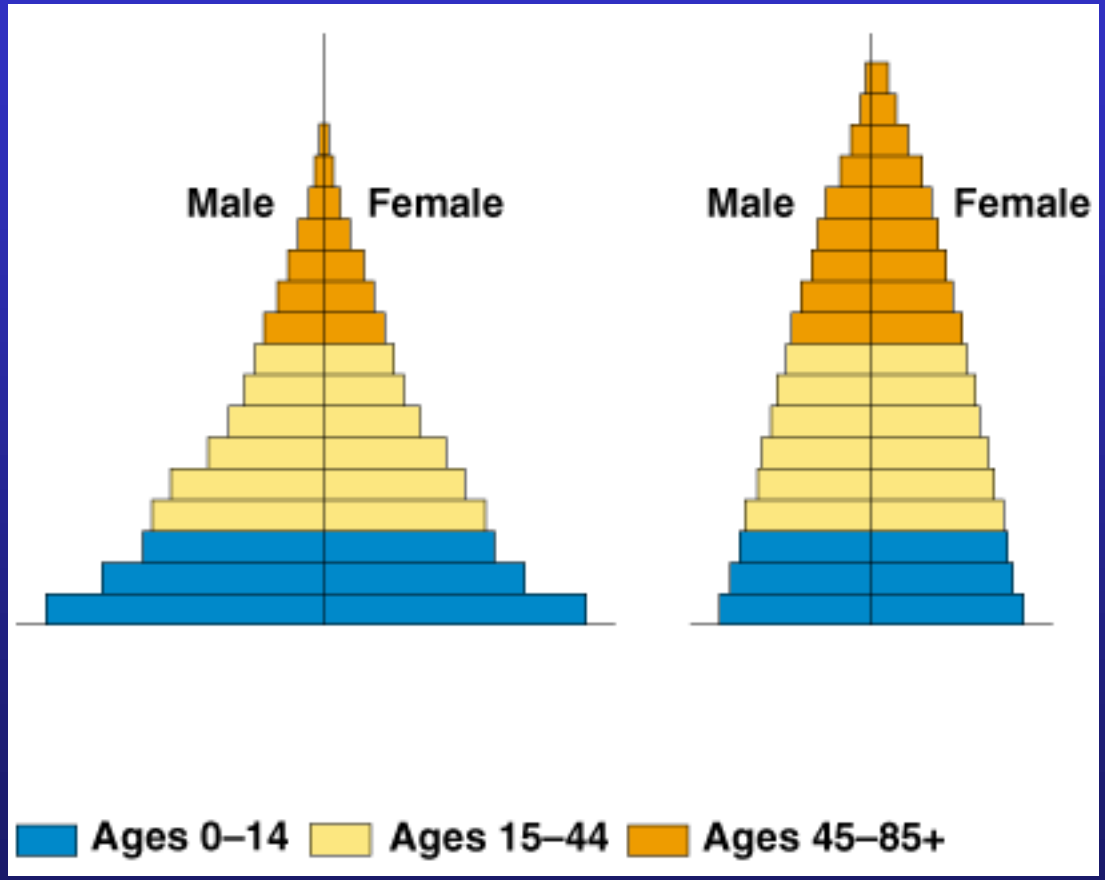
- Which "type" of countries are going to see most of the population growth?
- Which "type" of countries do people live longer lives?
- Survivorship: percent of population likely to survive a given age



Population Age Structure

Age structure of a rapidly growing vs. a slower growing population.

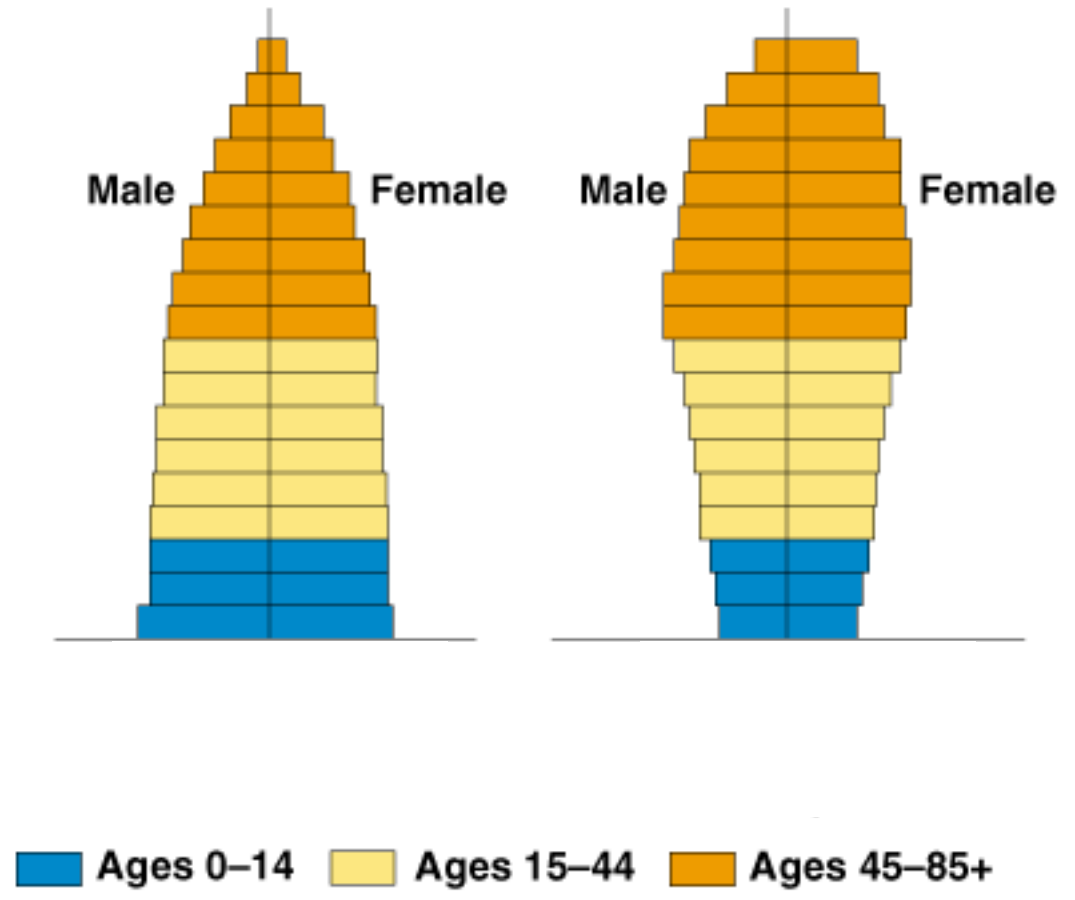
Rapidly growing populations have pyramid–shaped age structures, with large numbers of pre-reproductive individuals. Slower growing populations have a more even age distribution.



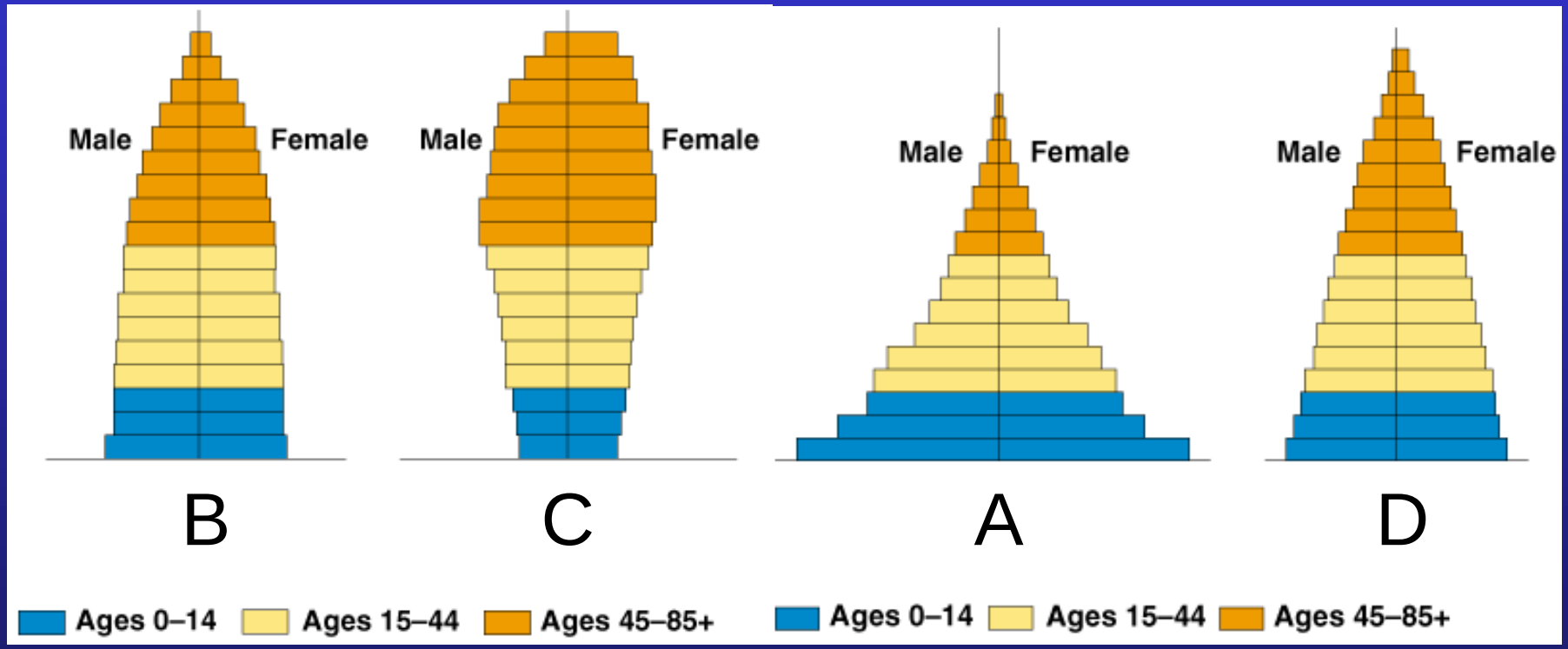
Population Age Structure

Age structure of populations with zero growth vs. negative growth.

Populations with zero population growth have nearly equal proportions of pre-reproductive & reproductive individuals; whereas populations with negative growth have a greater proportion of reproductive than pre-reproductive individuals.

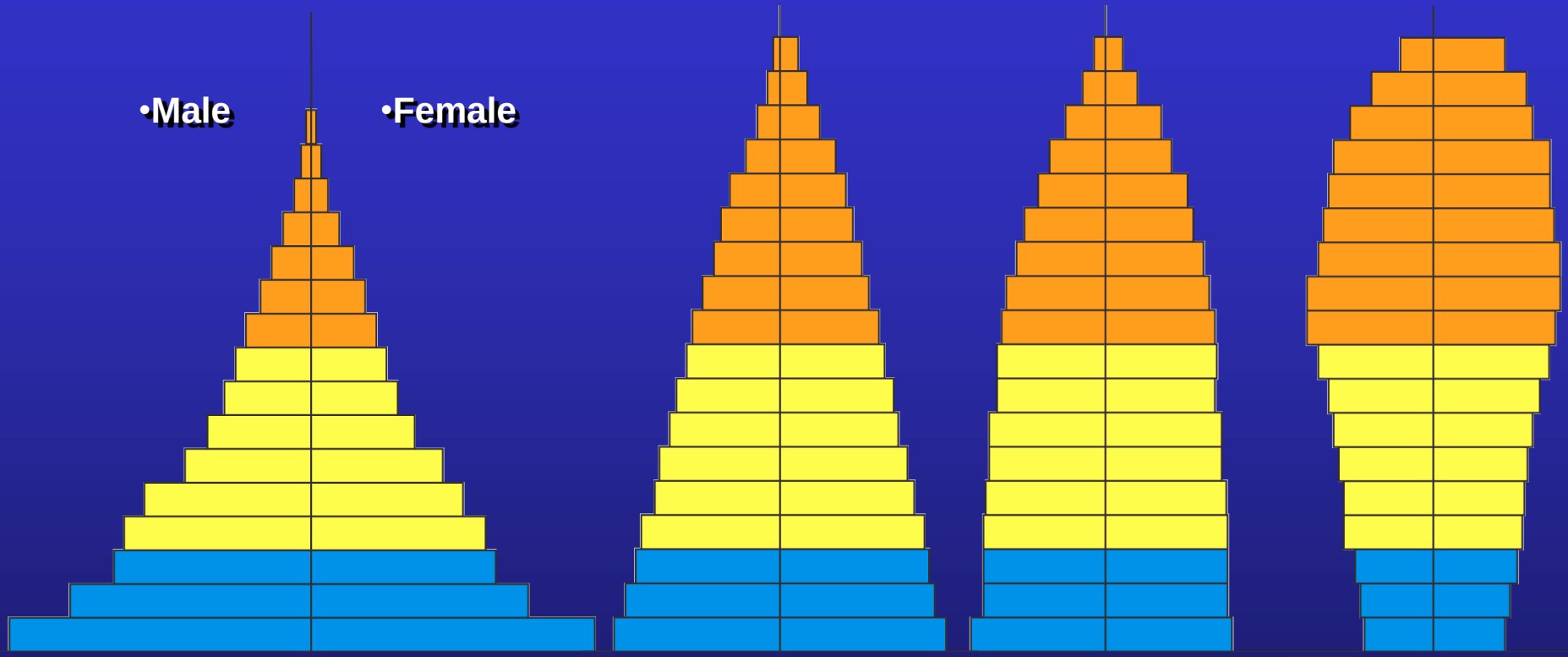


Matching Review



A. Rapid Growth
B. Zero Growth
C. Negative Growth
D. Slow Growth

Population Age Structure



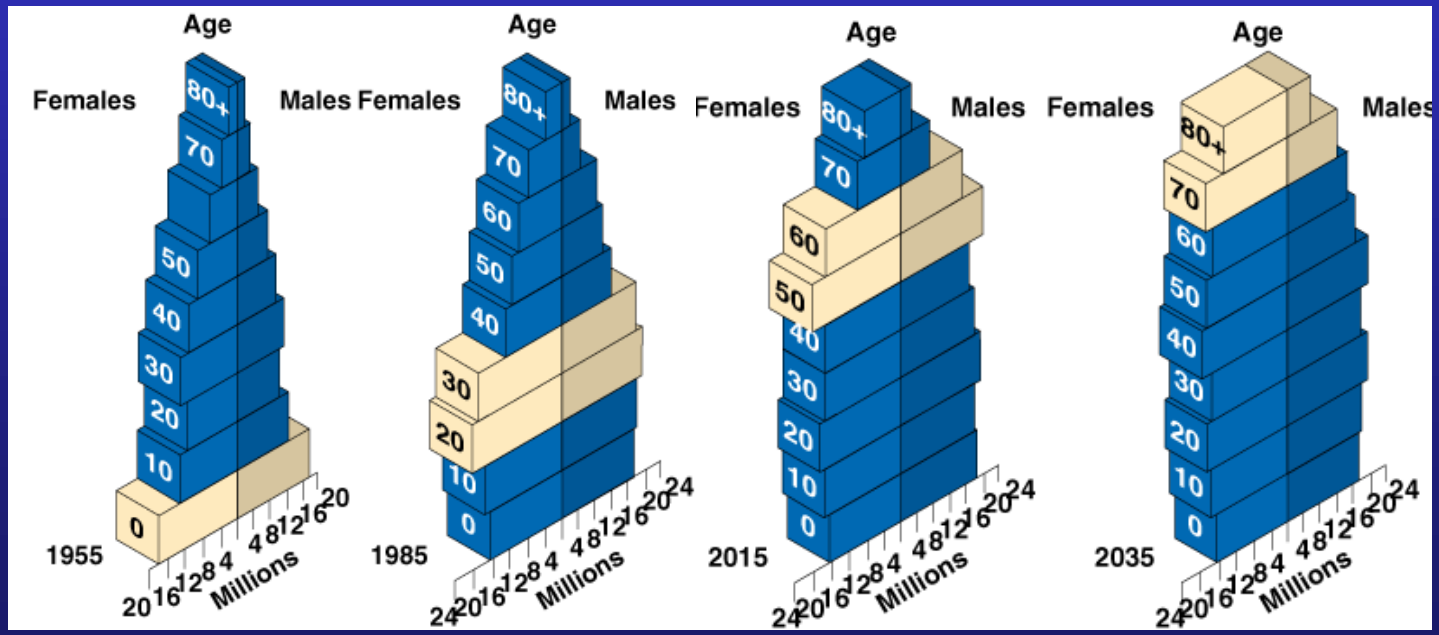
•Rapid Growth	•Slow Growth	•Zero Growth	•Negative Growth
•Guatemala	•United States	•Spain	•Germany
•Nigeria	•Australia	•Austria	•Bulgaria
•Saudi Arabia	•Canada	•Greece	•Sweden

•Ages 0-14 •Ages 15-44 •Ages 45-85+

•Fig. 10-14 p. 184

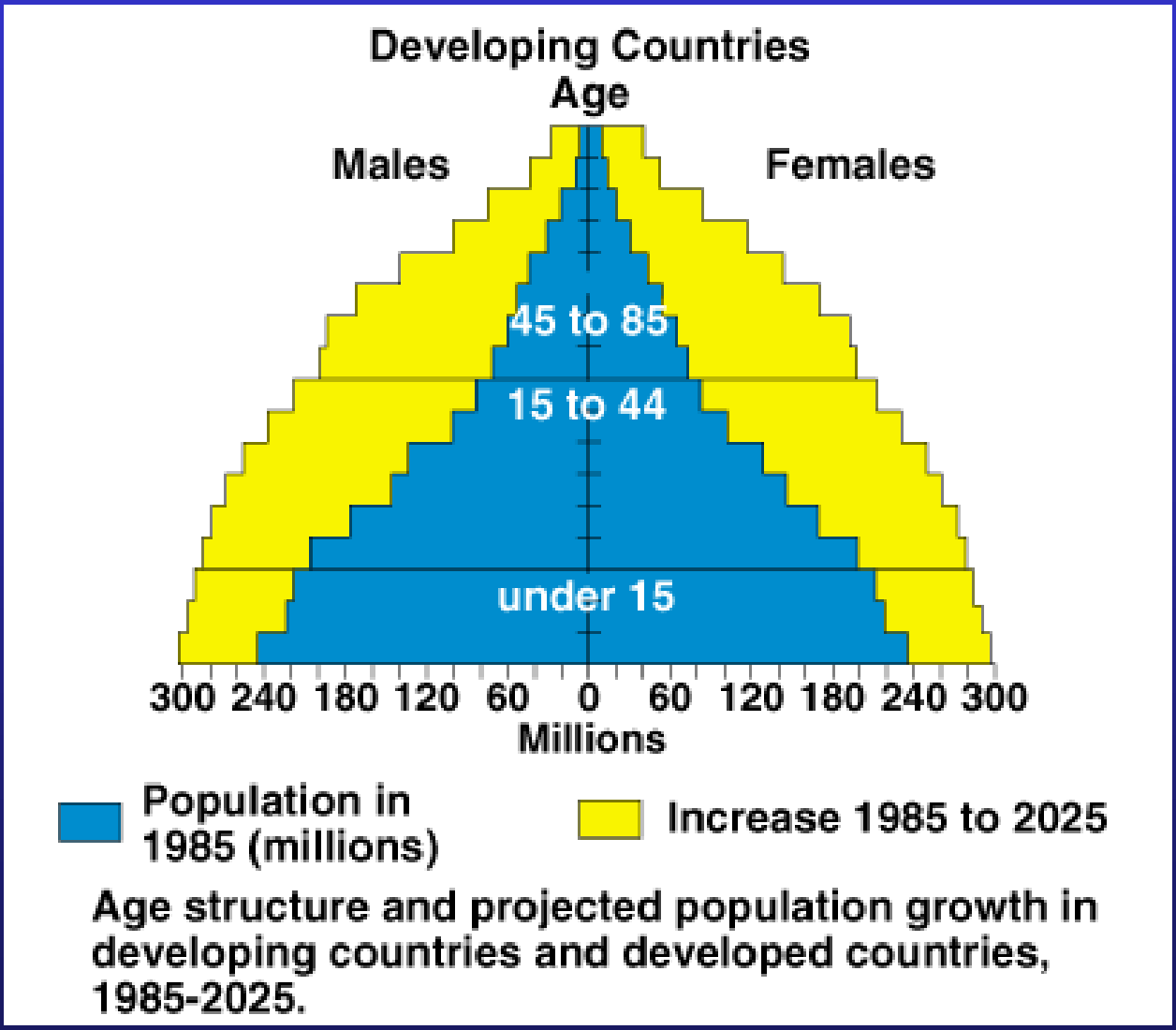
Population Age Structure

Population age structure of the United States continues to show a bulge as the "baby boom" generation ages. This has been compared to watching a boa constrictor swallow a pig.



Population Age Structure

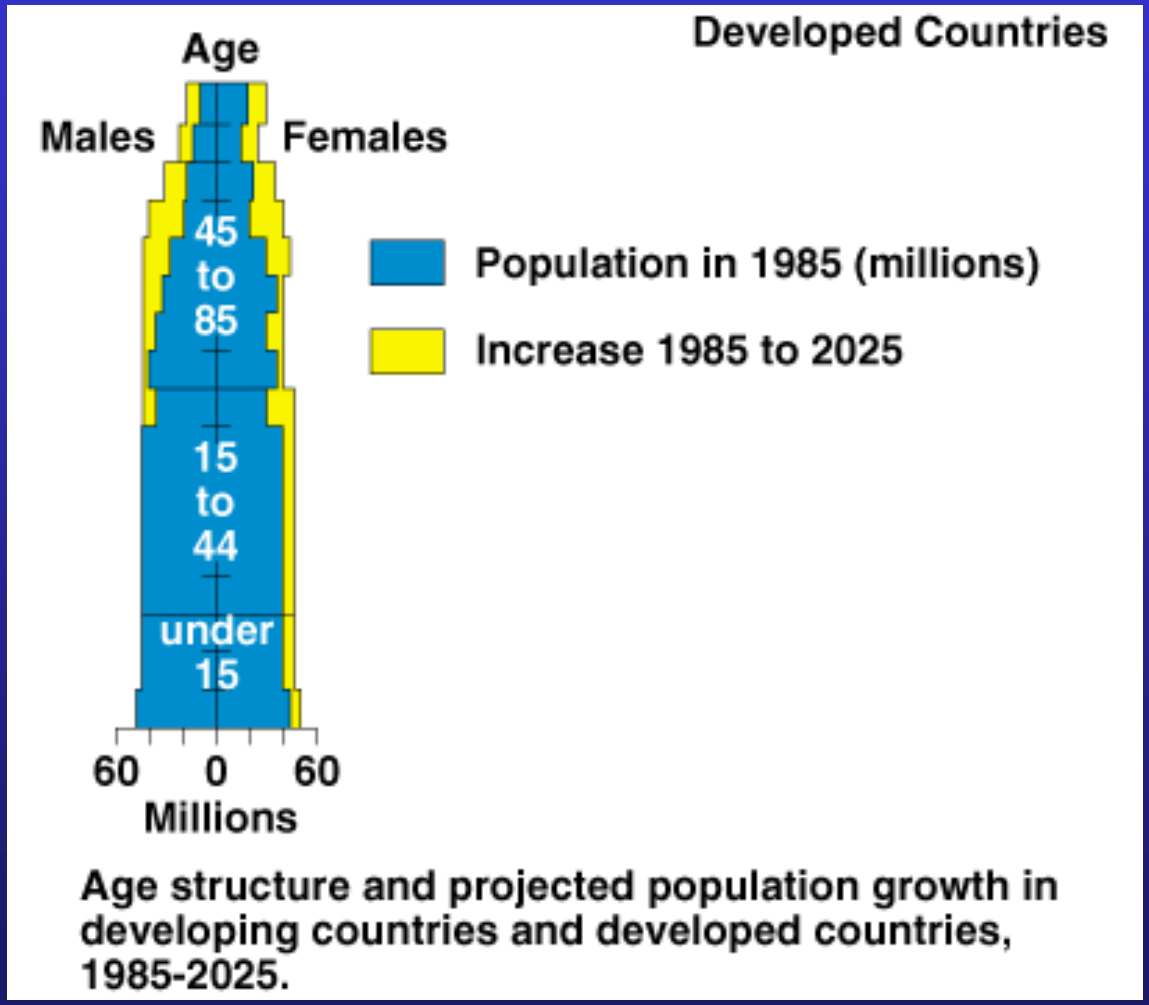
Developing countries *are expected to continue to have a pyramid shape through the year 2025, although the age structure will become somewhat more evenly distributed.*



Age structure and projected population growth in developing countries and developed countries, 1985-2025.

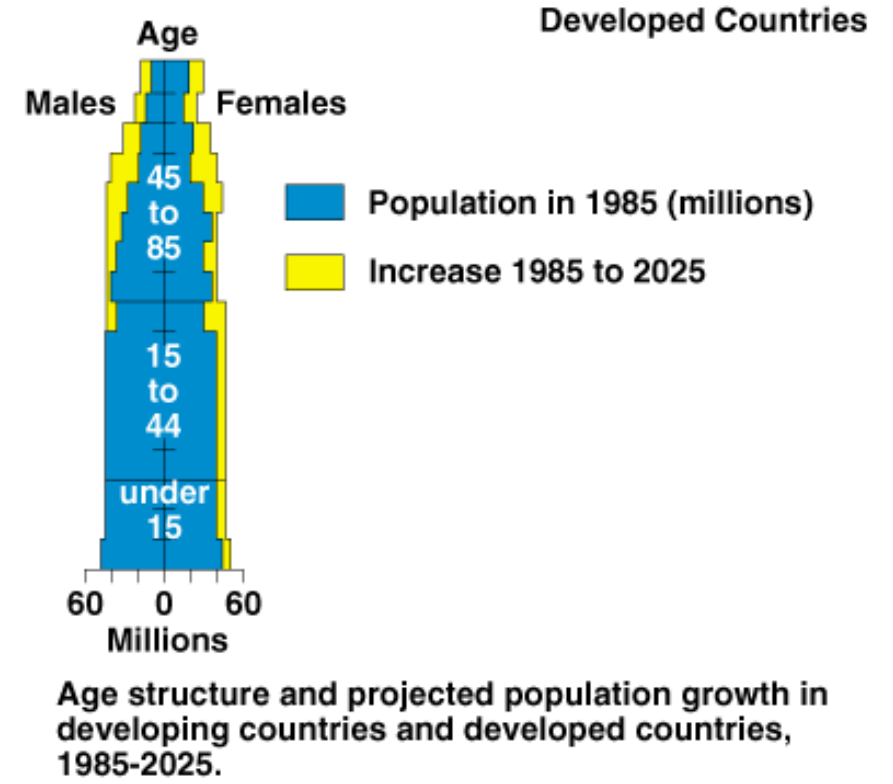
Population Age Structure

Populations of ***developed countries*** *are expected to have an increasingly even age distribution through the year 2025.*

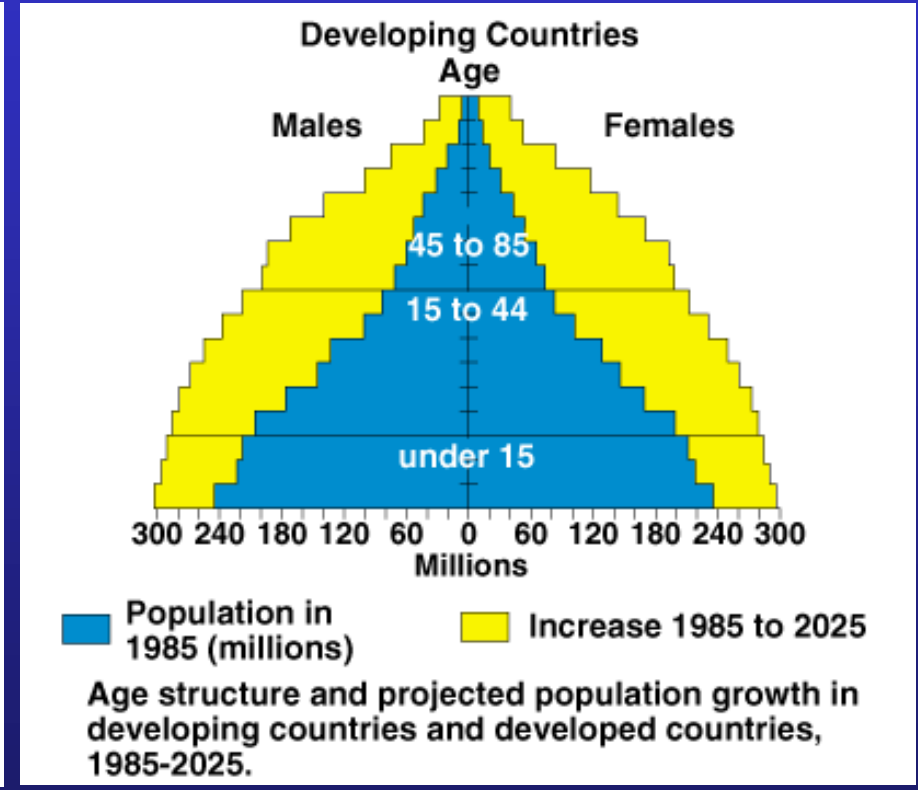


Age structure and projected population growth in developing countries and developed countries, 1985-2025.

Developed vs. Developing



Age structure and projected population growth in developing countries and developed countries, 1985-2025.



Age structure and projected population growth in developing countries and developed countries, 1985-2025.

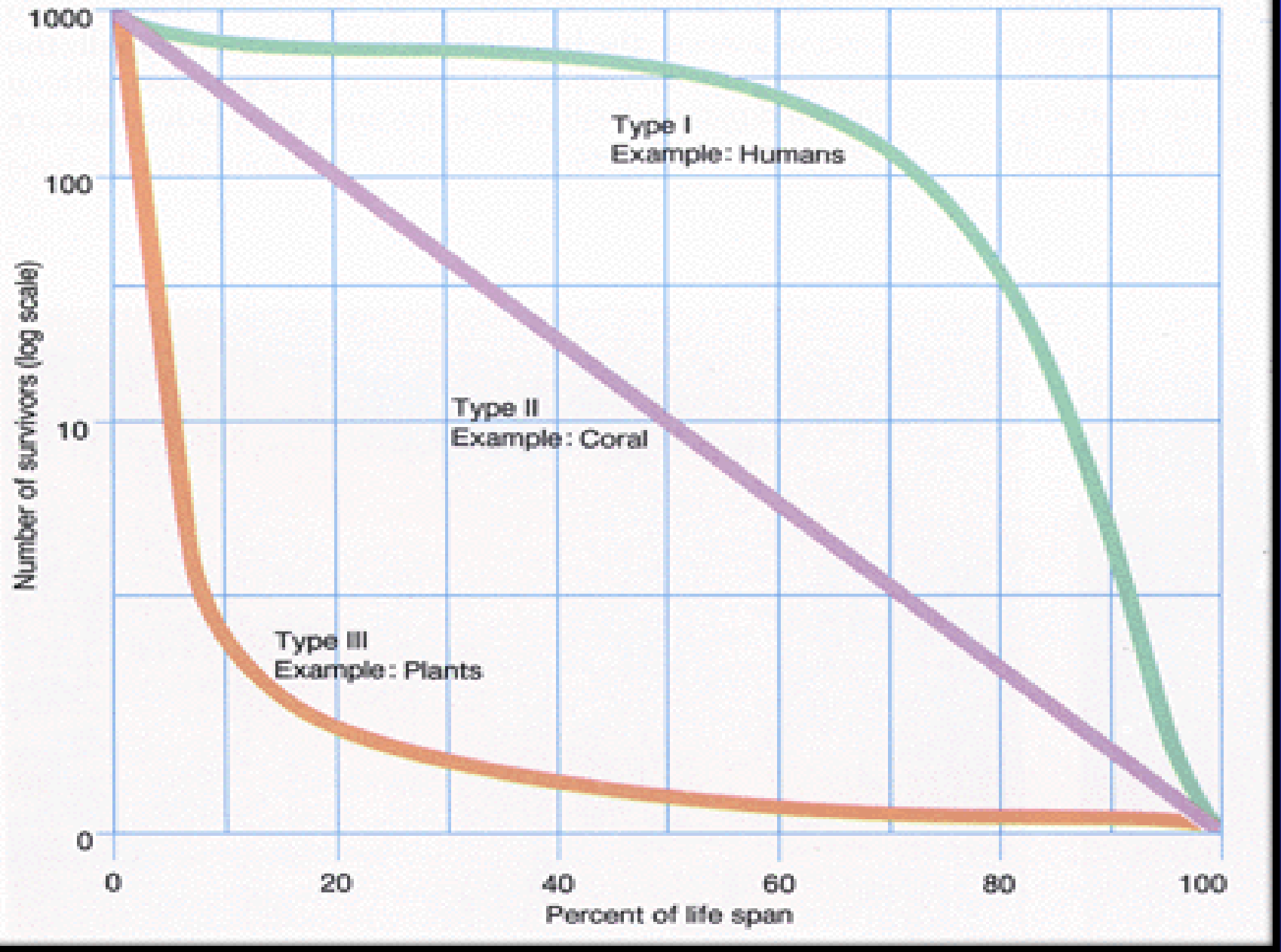
Patterns of Mortality

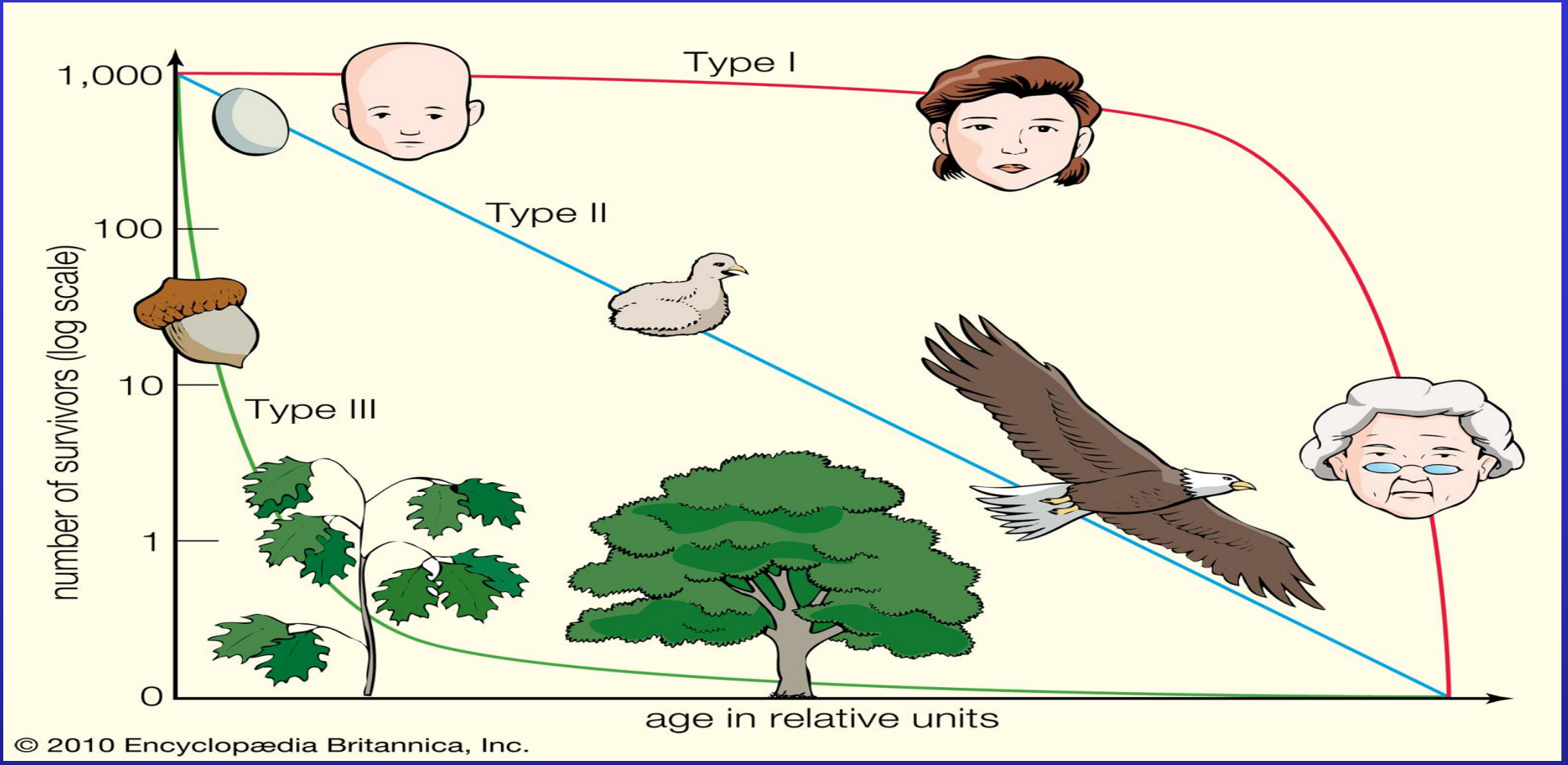
- Mortality data of different species tends to match one of three curves

- **Survivorship curves**-show the probability that members of a population will survive to a certain age
- Type I, Type II, and Type III curves

Survivorship Curves

- **Type I Curve**- high survival in early and middle life, rapid decline of survivorship in later life (human, elephant)
  - Likelihood of dying increases with age
- **Type II Curve**- probability of dying does not change throughout life; constant mortality rate regardless of age (certain birds, corals, squirrels, many reptiles)
- **Type III Curve**- high mortality rate in early life – due to species that produce large number of offspring (oyster, salmon, insect, plants)


1000
100
10
0
Number of survivors (log scale)
Type I
Example: Humans
Type II
Example: Coral
Type III
Example: Plants
0
20
40
60
80
100
Percent of life span



If a tree wants to successfully reproduce, how many seeds should it spread?

If a couple in India knows for sure there child will survive to adulthood, will they decide to have more or less children do you think?