Chapter 15:
Is the Human Population Too Large?

***with Population Ecology

Biology 1020:
CURRENT TOPICS IN BIOLOGY

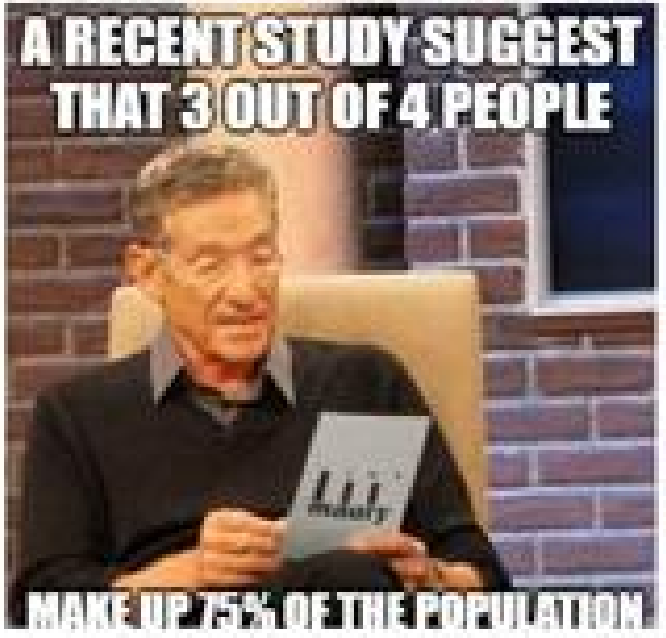
What is the approximate population of the world?

A. 73 million

B. 173 million

C. **7.3 billion**

D. 73 billion

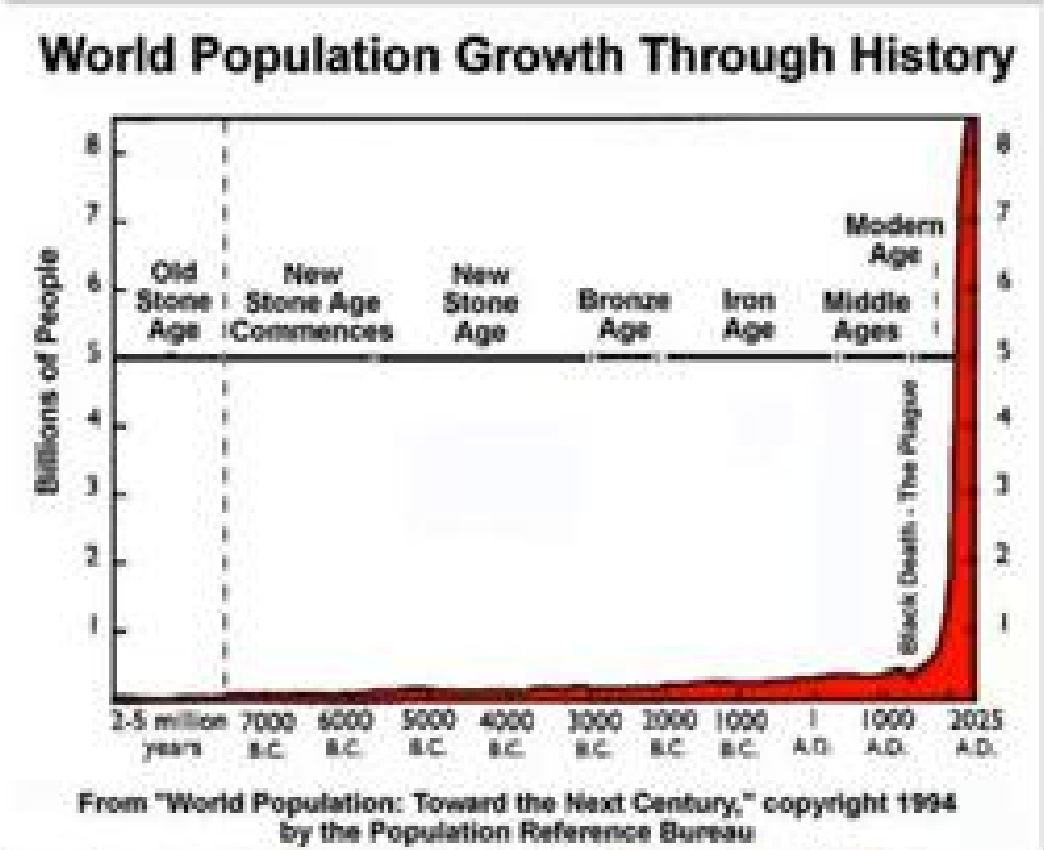


***In 2015, the UN's estimate for the world population was 7.3 billion people.

Introduction

World population

- 2015: UN estimated 7.3 billion people
  - 4 billion more than 50 years ago
- 2100: population will stabilize between 10–12.5 billion
- Can our planet support 5.2 billion more people?
- Would everyone have the same level of support?
  - 2016: 795 million people are "food insecure"
  - 3 million children under age 5 are malnourished



Population Growth

Ecology: study of the interactions among organisms, as well as between organisms and their environment

Population: all the individuals of a species in a given area

(able to create viable fertile offspring with each other)

Population Growth

Population structure: characteristics of a population

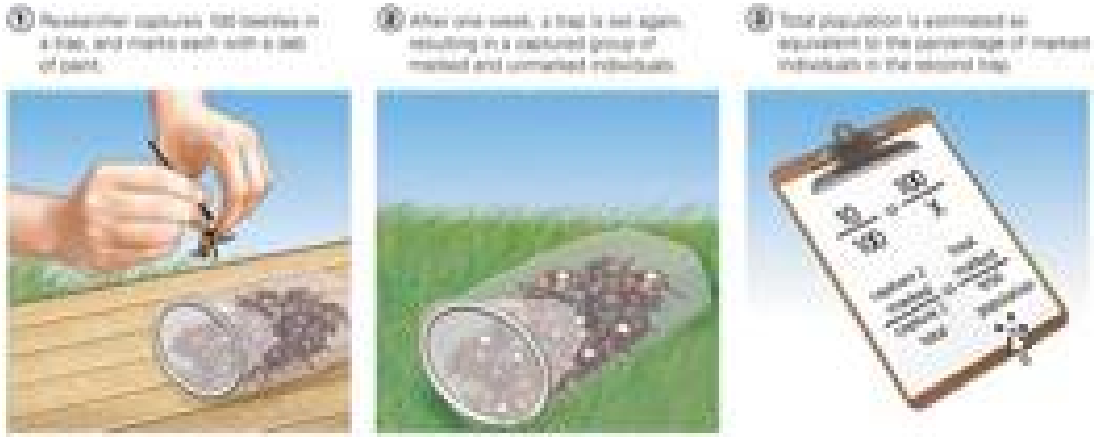
- Distribution: the spacing of individuals
- Abundance: the density of individuals
- Ecologists explain distribution and abundance of individuals
  - Examine influential factors of success and failure
    - Interactions among species
    - Internal dynamics of the population
      - Relative numbers of sexes and ages

Population Growth

Population size: estimated by population ecologists

- Direct counting
  - Individuals are counted or surveyed
  - E.g., U.S. Census

- Mark-recapture method
  - Estimates the size of more mobile or inconspicuous species



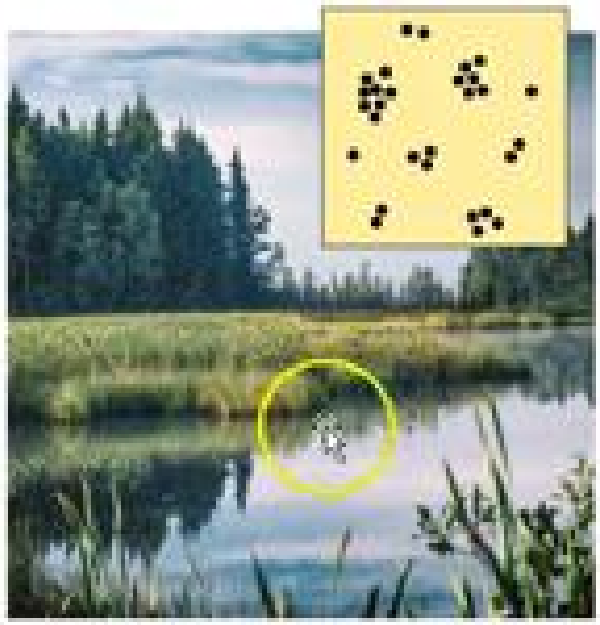
BioFlix: Population Ecology

Population Growth

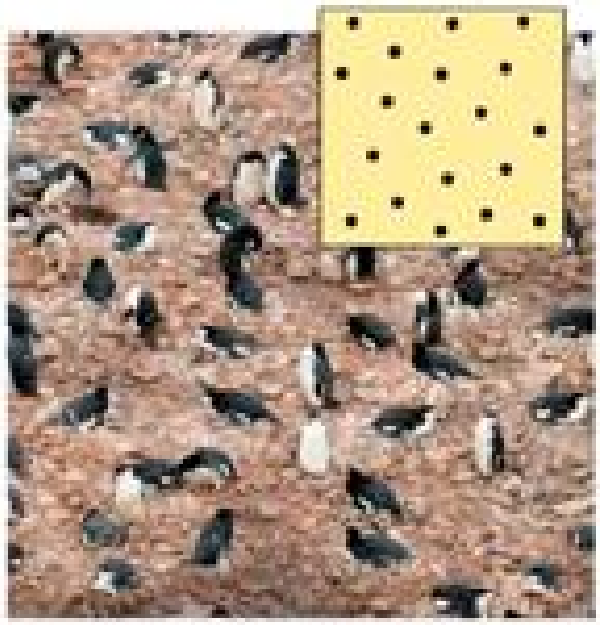
Population dispersion: how organisms are distributed in space

- Clumped distribution
- Uniform distribution
- Random distribution

(a) Clumped



(b) Uniform



(c) Random

On a global scale, what type of population distribution do humans show?

A. **clumped distribution**

B. homogeneous distribution

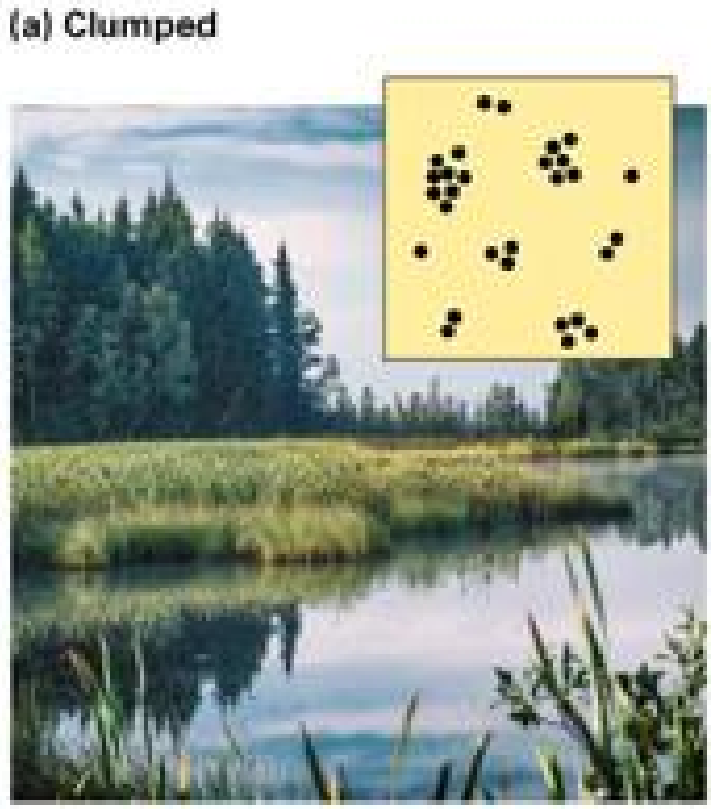
C. random distribution

D. uniform distribution

Population Growth

Clumped distribution

- High densities in resource-rich areas
- Low densities elsewhere
  - Globally, humans are clumped around transportation resources (rivers and coastlines).
  - Plants and animals clump around food and energy sources.

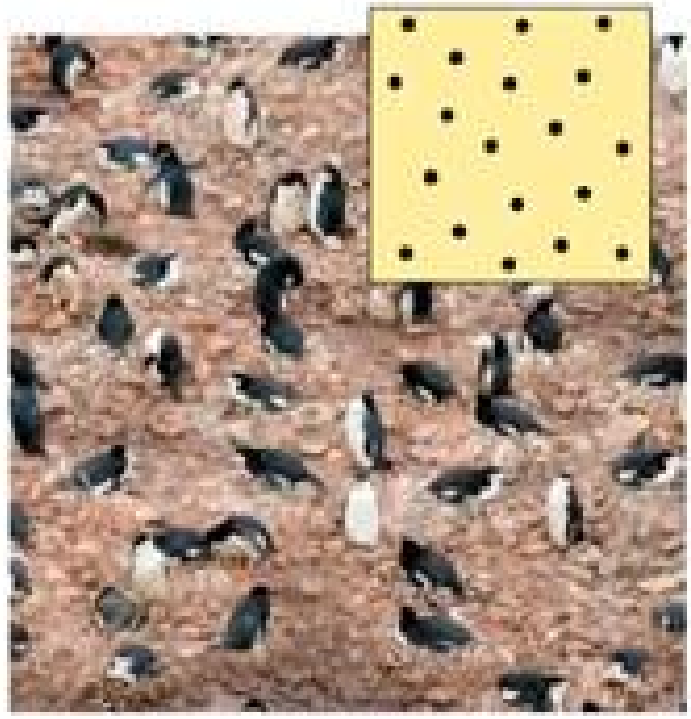


Population Growth

Uniform distribution

- Spacing between individuals tends to be equal
  - Examples:
    - Spacing between human houses on a local level
    - Territorial species

(b) Uniform



Population Growth

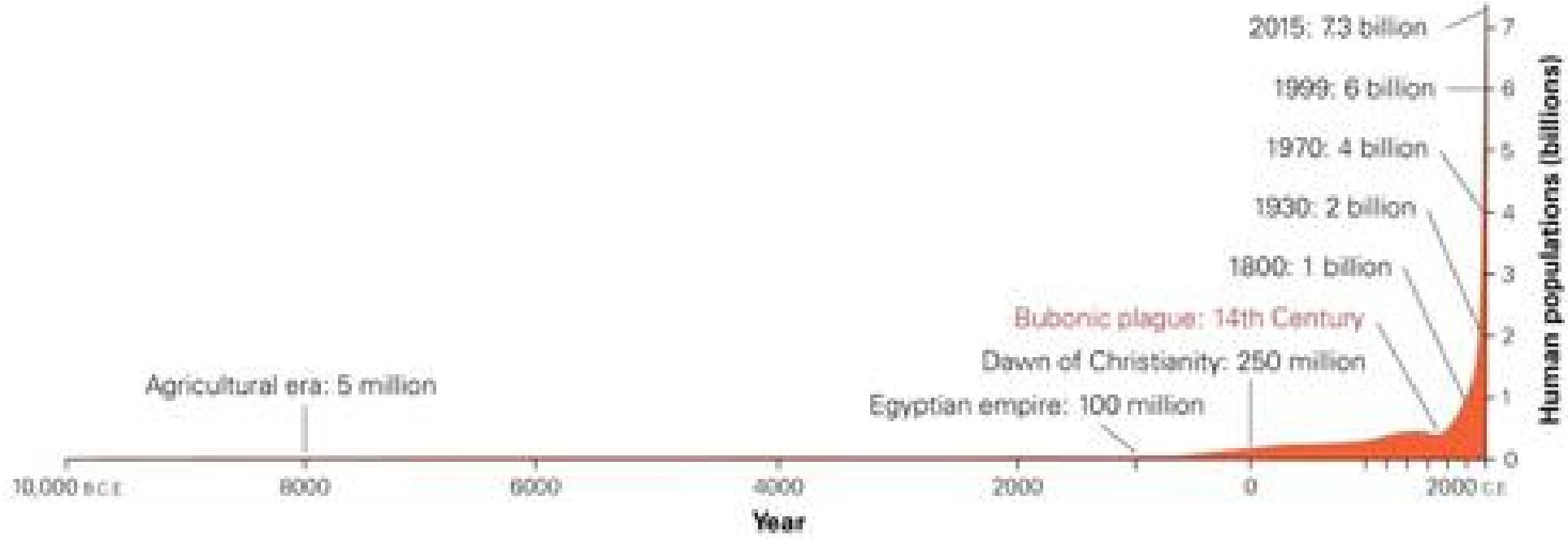
Random distribution

- Shown by nonsocial species with ability to tolerate wide range of conditions
- No compelling factor brings individuals together or pushes them apart.
  - Trees with windblown seeds

Population Growth

Human population growth

- Historians determined human population sizes over past 10,000 years.
  - Archaeological evidence
  - Written records
- Shows **exponential growth**: occurring in proportion to the current total
- Graph of **exponential growth** shows J-shaped curve



Population Growth

Human Population

- Mostly low levels throughout history
- 10,000 years ago: agricultural era began
  - 5 million humans
- 3,000 years ago: during Egyptian empire
  - 100 million people
- 1 CE: dawn of Christian religion
  - 250 million people
- Growth rate was ~0.1%

Population Growth

Growth rate of human population

- 1750: growth rate was ~2% per year
- 1800: 1 billion people
- 1930: 2 billion people
- 1970: 4 billion people

Population Growth

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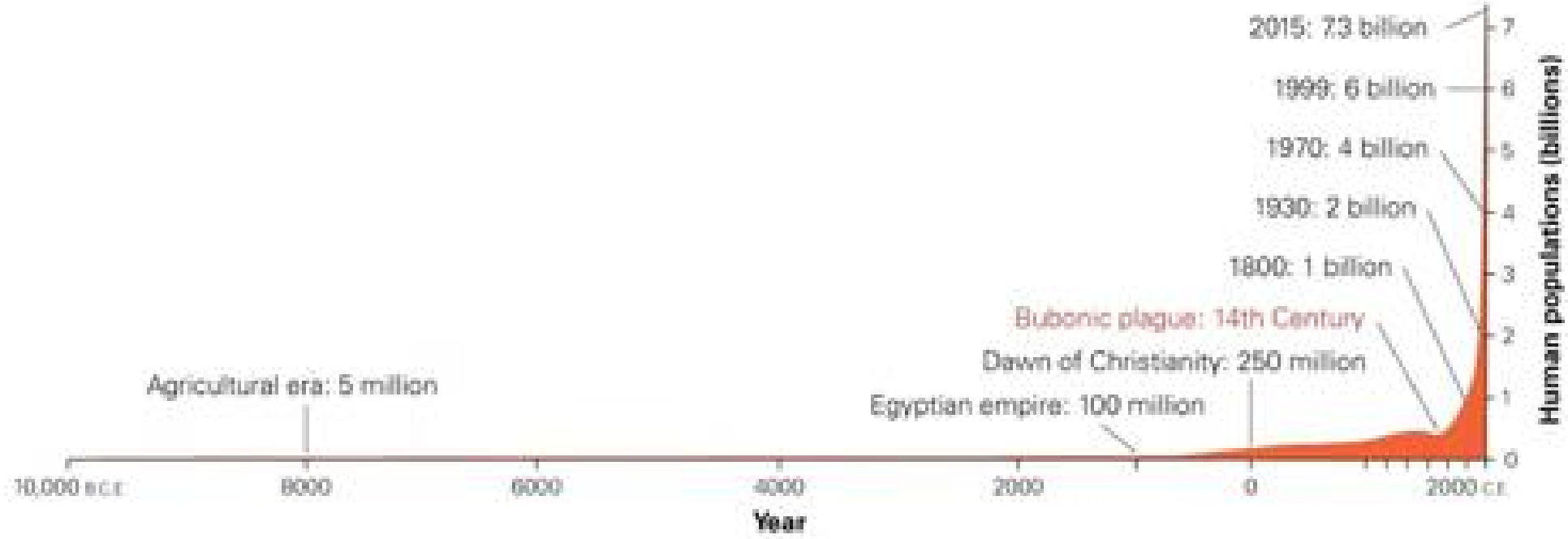


Population Growth

Growth rate of human population

- Current growth rate = ~1.1% per year
- Current population = 7.3 billion people
  - 83 million people added each year: more than combined populations of California, Texas, and New York
  - 250,000 people added every day
  - Three people added every second

Growth rate = _____

A. Birth rate × Death rate

B. Birth rate − Death rate

C. Death rate + Birth rate

D. Death rate − Birth rate

Population Growth

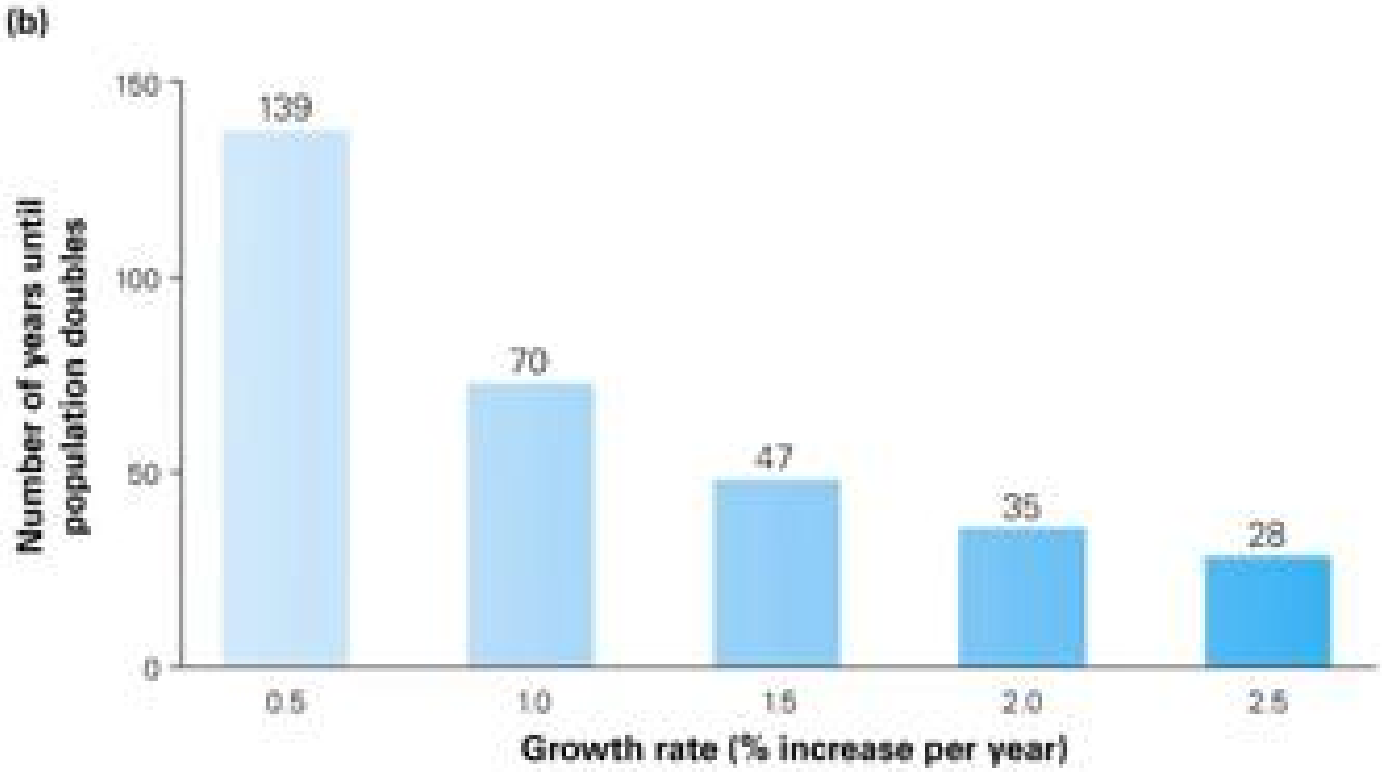
Growth rate of human population

- Growth rate = r = birth rate − death rate
  - Birth rate – the number of births as a percentage of the population
    - 21 babies born per year per 1000 people
      - Birth rate = 21/1000 = 0.021 = 2.1%
  - Death rate – the number of deaths as a percentage of the population
    - 10 people die per year per 1000 people
      - Death rate = 10/1000 = 0.01 = 1%
  - Current growth rate = 2.1% − 1% = 1.1%

Population Growth

Growth rate of human population

- Growth rate = 0.1
  - Population doubles in 693 years
- Growth rate = 1.1%
  - Population doubles in 63 years



Population Growth

Demographic transition: the period when birth rates are dropping toward lowered death rates

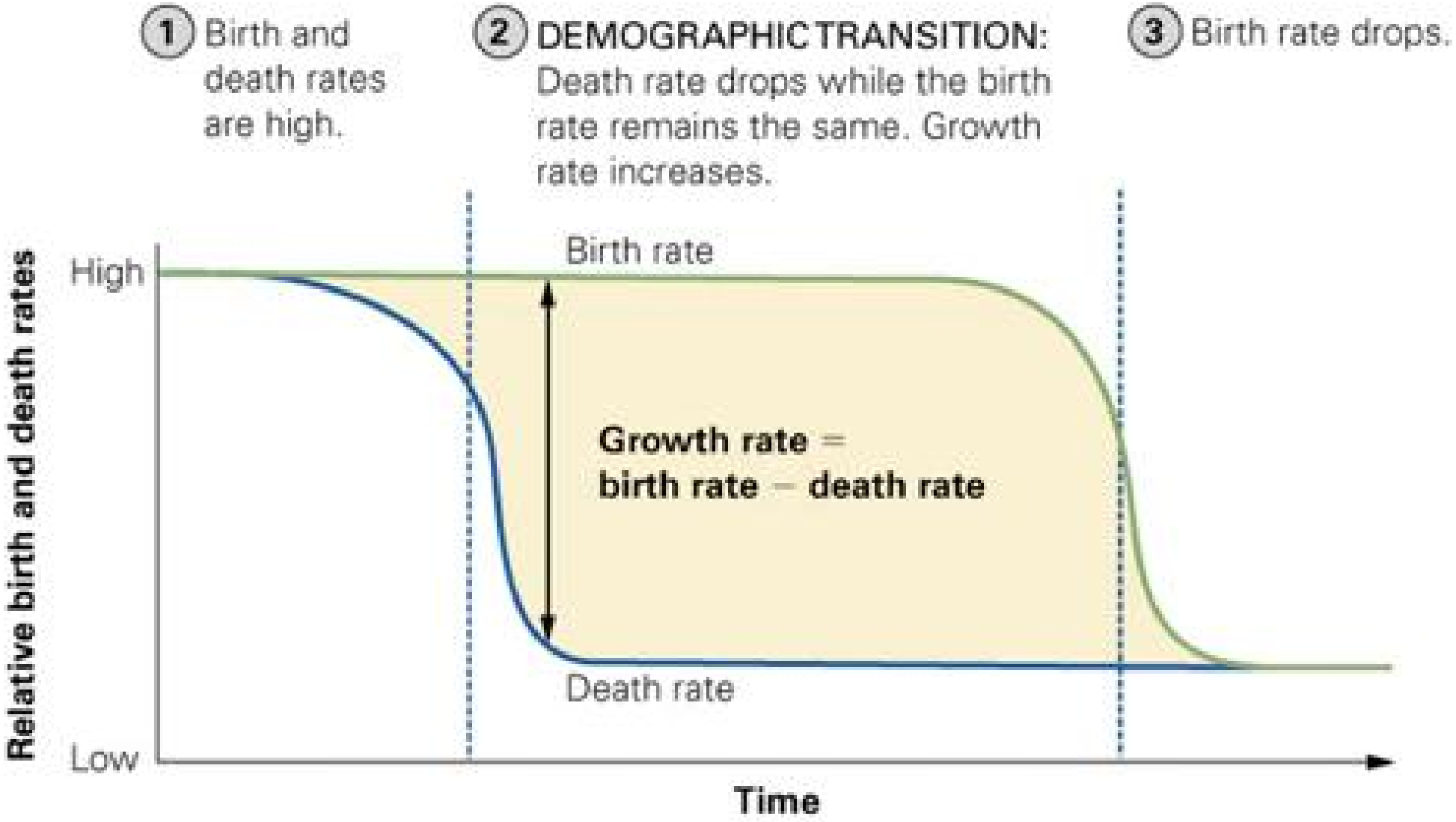
- Pre-industrial revolution: high birth and death rates
- 18th century (industrialization): deaths decreased
  - Decreased infant mortality
  - Advanced treatment and prevention of infectious diseases

Population Growth

Demographic transition: the period when birth rates are dropping toward lowered death rates

- Transition time affects population size
  - Developed countries: short transition, low growth
    - Industrial economies and high individual incomes
  - Less developed countries remain in demographic transition.
    - Starting industrialization, low incomes
    - Decreased deaths and high birth rates
    - Decreased infant mortality due to:
      - Pesticide use to decrease malaria
      - Immunization programs and antibiotic availability

Population Growth



Limits to Population Growth

Growth in non-human species

- Studies show clear limits to population size.
  - 1990s: elk in Yellowstone Park
    - Large population degraded rangeland (food supplies)
    - High winter mortality
  - Norway lemmings:
    - massive migrations every 5 to 7 years
      - lead to deaths from overcrowding
    - Loss of high-quality food forces dispersal

Limits to Population Growth

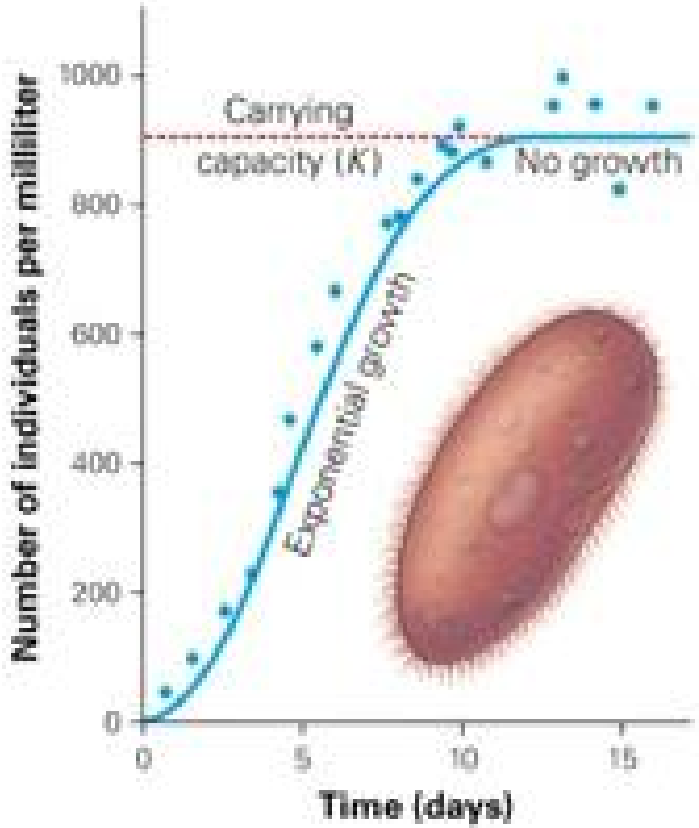
Carrying capacity: the maximum population that can be supported indefinitely in a given environment

- Populations may grow exponentially
- Limited by environmental resources
  - Food
  - Water
  - Shelter
  - Space

Limits to Population Growth

Logistic growth: pattern of growth seen in populations limited by environmental resources

- Observed in lab populations of flour beetles, water fleas, and protists
- Graph of resource-limited growth has S-shaped curve



Limits to Population Growth

Density-dependent factors: population-limiting factors that increase with population size

- Limited food supply
- Increased risk of infectious disease
- Increase in toxic waste levels

- Results in
  - Decreases in birth rates
  - Increases in death rates
    - Fruit flies: High populations lead to increased mortality due to dwindling food supplies and accumulated waste

Limits to Population Growth

Density-dependent limits to growth

(a) Fruit flies

(b) *Daphnia*

(c) White-tailed deer

(d) Humans

Limits to Population Growth

Density-independent factors: influence population growth rates regardless of population density

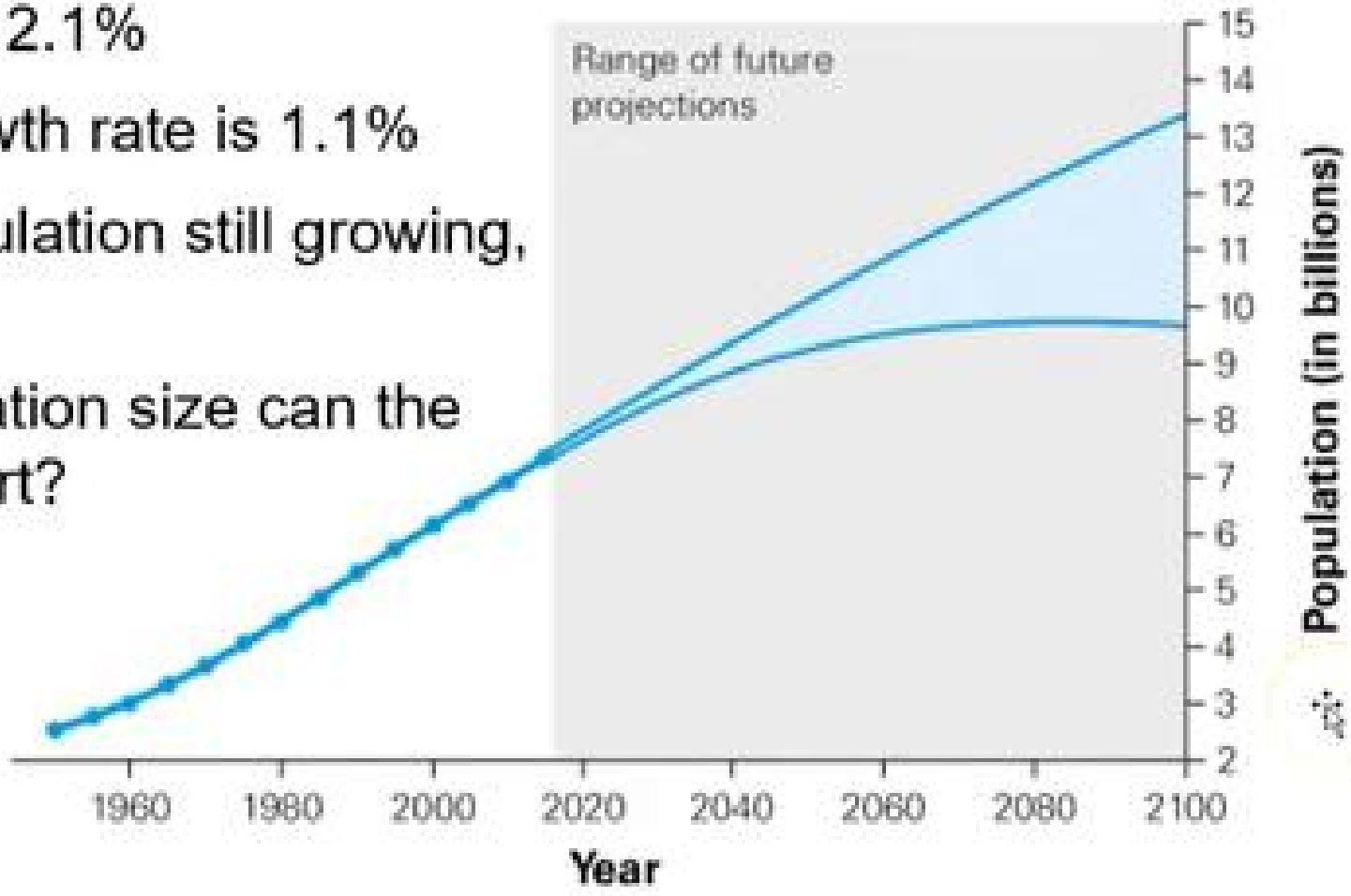
- Droughts
- Temperature extremes
- Natural disasters
  - More severe storms due to climate change impacts

- Severity of factor effects may depend on population size.
  - Competition for resources

Limits to Population Growth

Earth's carrying capacity for humans ???

- 1960s: highest population growth rate, 2.1%
- Current growth rate is 1.1%
- Human population still growing, but stable
- What population size can the Earth support?



Limits to Population Growth

Signs that population is not near carrying capacity

- Declining growth rate
  - Due to decreased death rates and decreased birth rates
- Decreased death rate despite rapid population increases
  - Indicates people don't run out of resources
- Declining birth rate
  - Due to choice of having fewer children

Limits to Population Growth

Signs that population is not near carrying capacity

- Estimated proportion of Earth's resources used by humans
  - Uses **net primary productivity (NPP)**: amount of food energy available
    - Humans use $\frac{1}{4}$ to $\frac{1}{3}$ of the total land NPP
  - Carrying capacity of Earth might be 21 billion people
    - Only humans would be supported by photosynthetic products

What carrying capacity for humans would result if Earth's total land net primary productivity was used?

A. 8 billion

B. 12.5 billion

C. **21 billion**

D. 40 billion

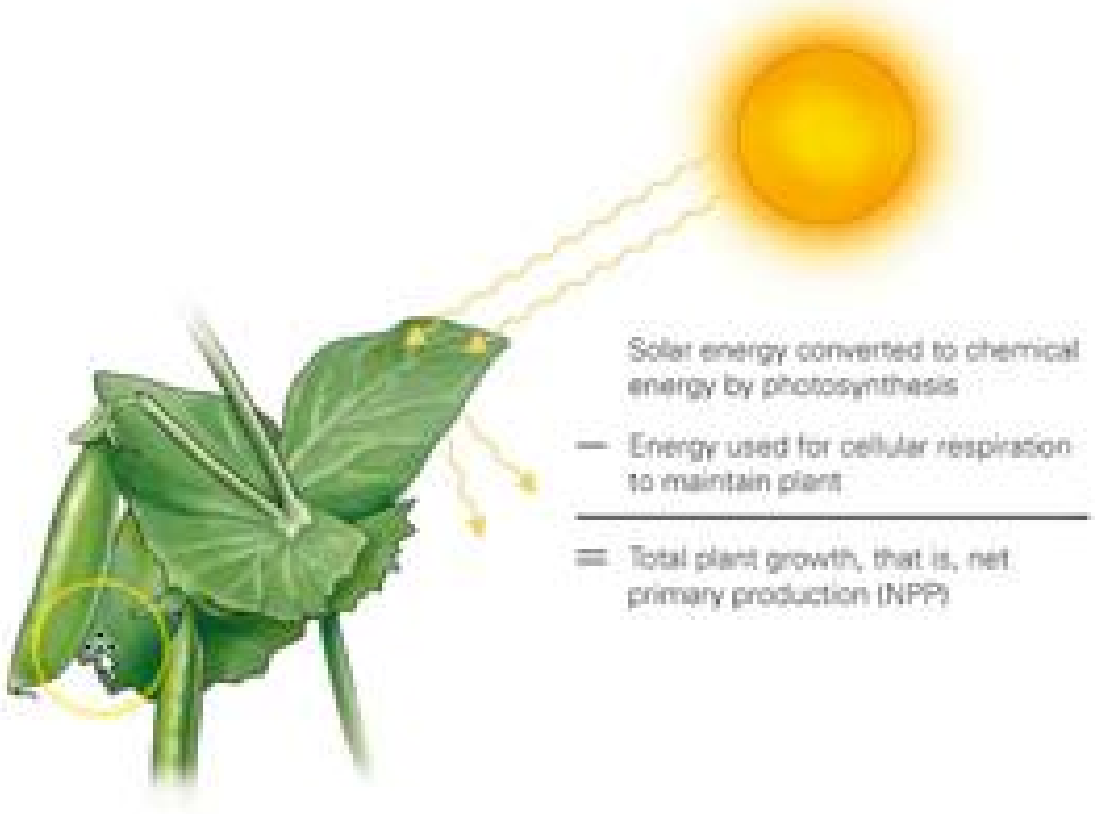
Limits to Population Growth

Signs that the population is near carrying capacity

- NPP estimates may be too high
- Other resources (besides food) sustain populations
  - Clean water
  - Clean air
  - Energy for heating, producing food, and preserving food
- Resource use produces pollution
  - Difficult to estimate clean water supplies

Limits to Population Growth

Net primary productivity (NPP): Measures plant growth over a single year



Limits to Population Growth

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Limits to Population Growth

Non-renewable resources: one-time stock resources that cannot be easily replaced

- Include many essential supplies that sustain current human population
- Fossil fuels: buried remains of ancient plants transformed by heat and pressure
  - Coal
  - Oil
  - Natural gas
- Use of fossil fuels depends on population size and average lifestyle.

Limits to Population Growth

American use of resources

- Americans: 5% of Earth's population
  - Consume 24% of global energy
  - Consume 815 billion food calories per day
    - 200 billion more calories than needed
    - Enough to feed 80 million people

Limits to Population Growth

American use of resources

- Average American uses as much as:
  - 2 Japanese or Spaniards,
  - 3 Italians,
  - 6 Mexicans,
  - 13 Chinese,
  - 31 Indians,
  - 128 Bangladeshis,
  - 307 Tanzanians, **or**
  - 370 Ethiopians

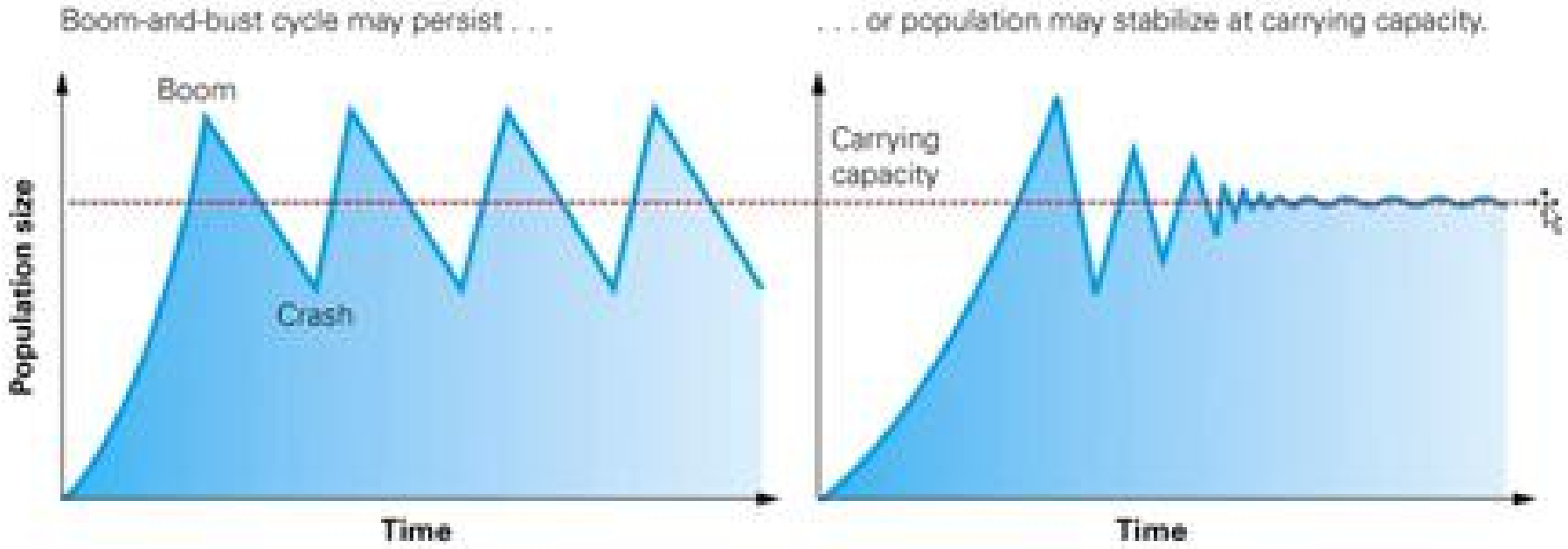
The Future of the Human Population

Growth beyond carrying capacity

- Population crash: steep decline in numbers
  - May result if population grows larger than carrying capacity of environment
- Population cycle: repeated periods of rapid growth followed by dramatic crashes; "booms" and "busts"
  - In species with high birth rates

The Future of the Human Population

Overshooting and crashing



The Future of the Human Population

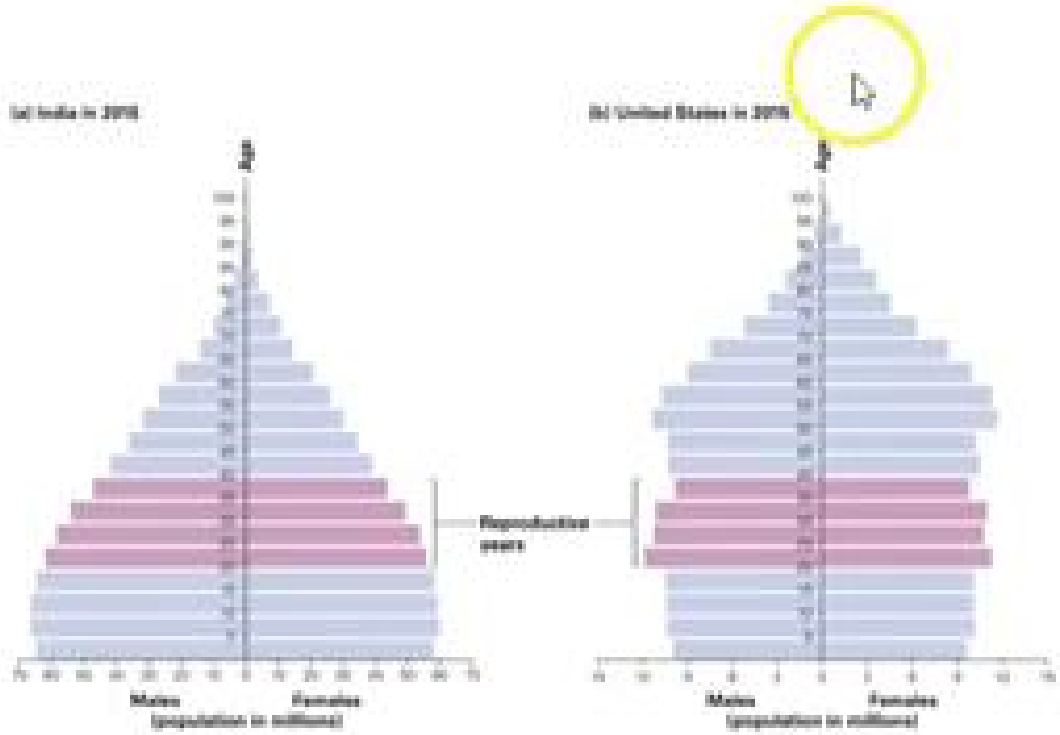
Demographic momentum: time lag between when humans reduce birth rates and when population growth begins to slow

- Parents reduce family size
  - Children grow and have children before parents die
- If parents have two children:
  - Population continues to grow for 60–70 years until stable.

The Future of the Human Population

Population pyramid: visual representation of individuals in age groups for each sex of a population

- Used to estimate demographic momentum
- A large base: large proportion of young people and the population is still growing



The Future of the Human Population

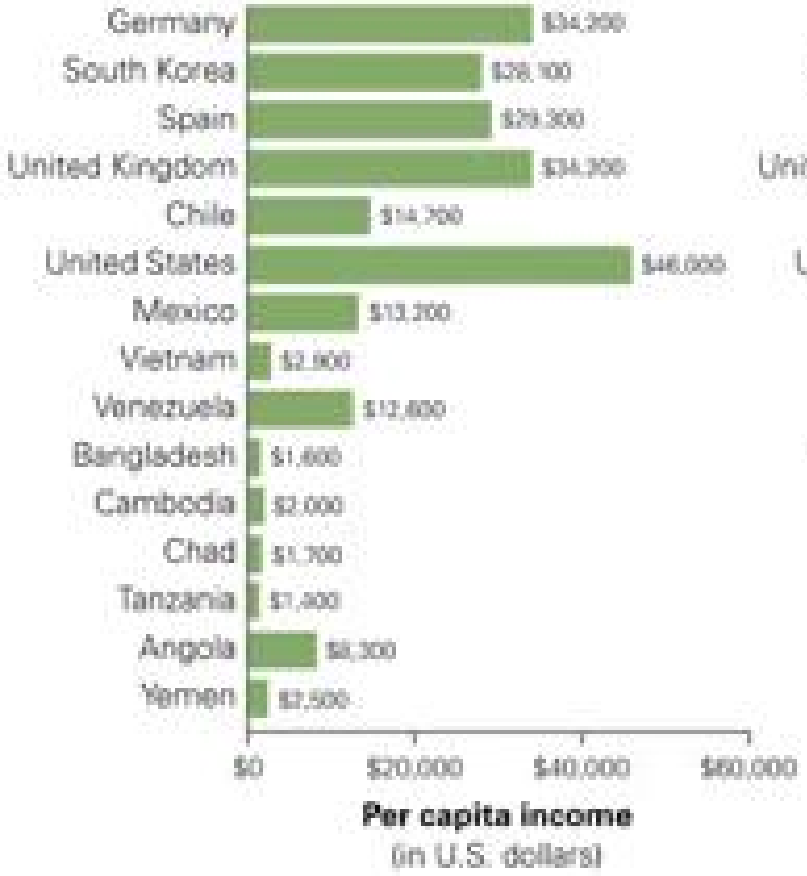
Avoiding disaster

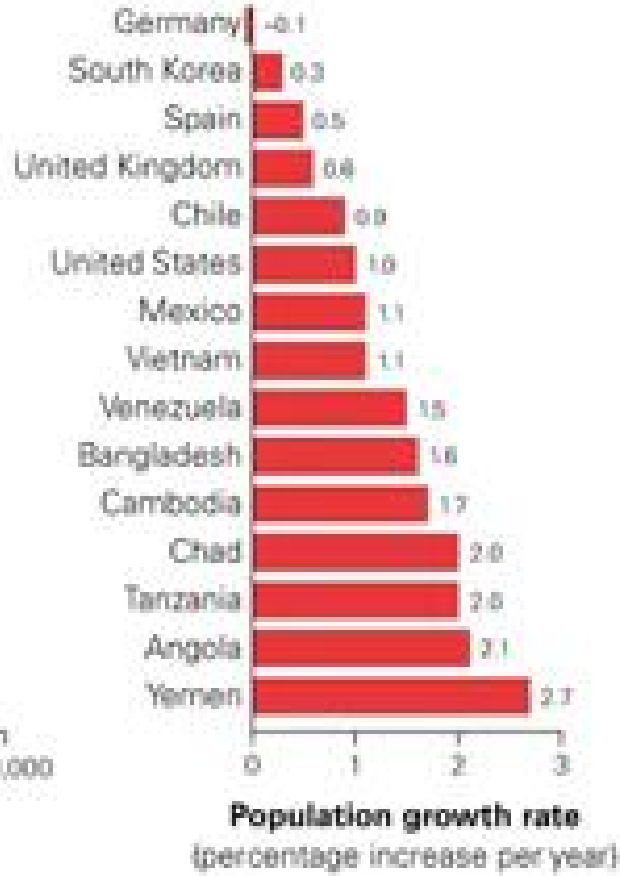
- Other factors affect population growth rate:
  - Income
  - Women's access to education (literacy)
    - Delayed motherhood
    - Fewer children

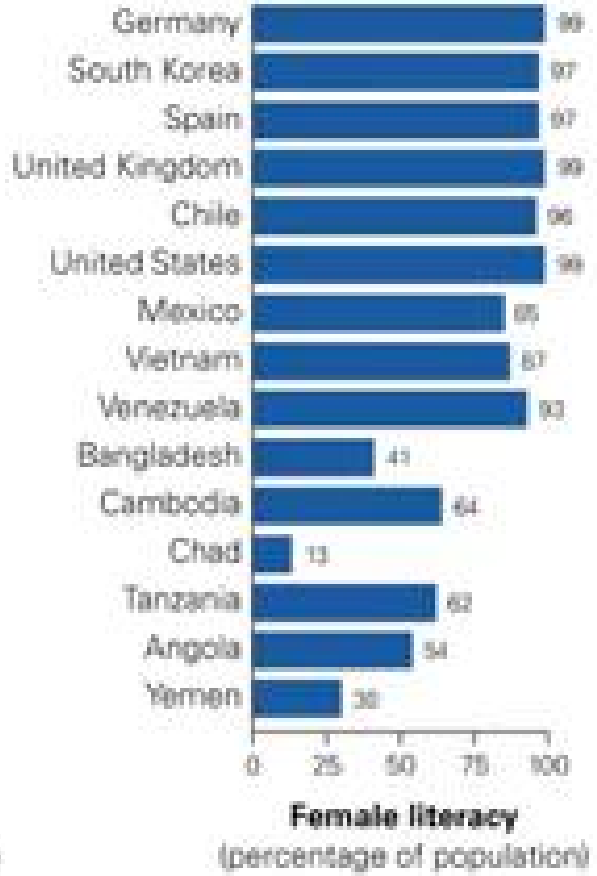
The Future of the Human Population

Income, growth rate, and women's literacy

- Play key roles in birth rates







The Future of the Human Population

Public policies to decrease population growth

- Improve conditions for women
  - Access to:
    - Education
    - Healthcare
    - job market
  - Provide information and tools to regulate fertility

The Future of the Human Population

Additional benefits of slowing population growth

- Cultural carrying capacity: quality of life issues
  - Wild, undisturbed places
  - Presence of nonhuman species nurturing wonder and discovery
  - Creating and enjoying music, art, and literature
- The questions of how many people the Earth can support, the quality of life, and support of nonhuman species are not just those of science, but of values and ethics.

The Future of the Human Population

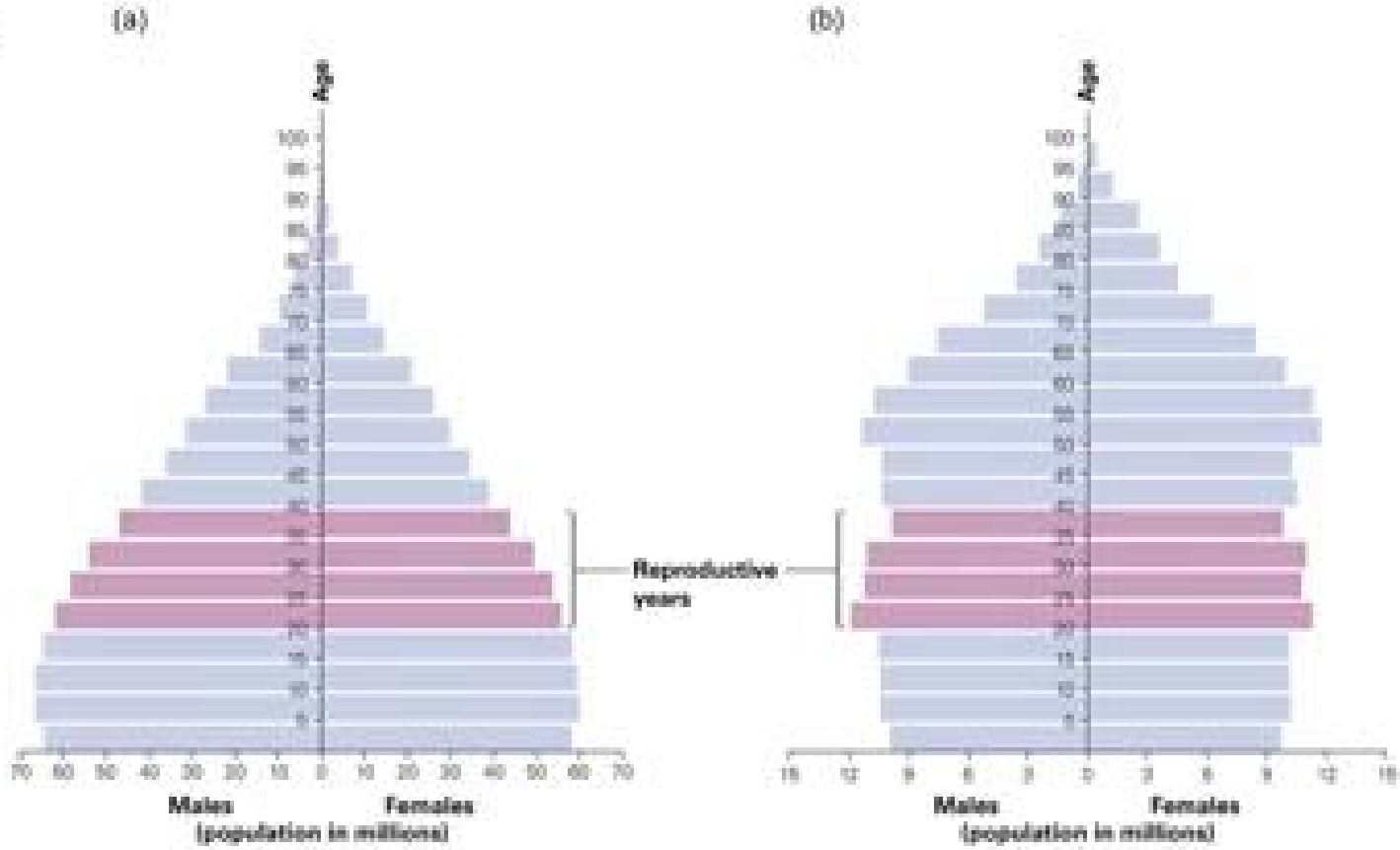
Public policies to decrease population growth

- Improve conditions for women
  - Access to:
    - Education
    - Healthcare
    - job market
  - Provide information and tools to regulate fertility

Which population model shows a rapidly growing population?

A. **pyramid a**

B. pyramid b



Answer: A

The population in India has a high birth rate and a large number of young individuals of reproductive age or that will soon be reaching reproductive age.

Review of Learning Outcomes

- Can you define ***population***, and describe the aspects of populations that are typically measured by ecologists?
- Can you describe how a mark-recapture estimate of population size is performed, and estimate the size of a population from mark-recapture data?
- Can you explain how the size of a population that is experiencing exponential growth changes over time?
- Can you describe the demographic transition in human populations and how it contributes to population growth?
- Can you define ***carrying capacity***, and explain its relationship to logistic growth?
- Can you compare and contrast the effect of density-dependent and density-independent factors on population growth?
- Can you list the evidence that the human population may not be near carrying capacity and the evidence that it may be near carrying capacity?
- Can you describe the conditions (in both human and other populations) under which a population crash can occur?