ECO CLUB

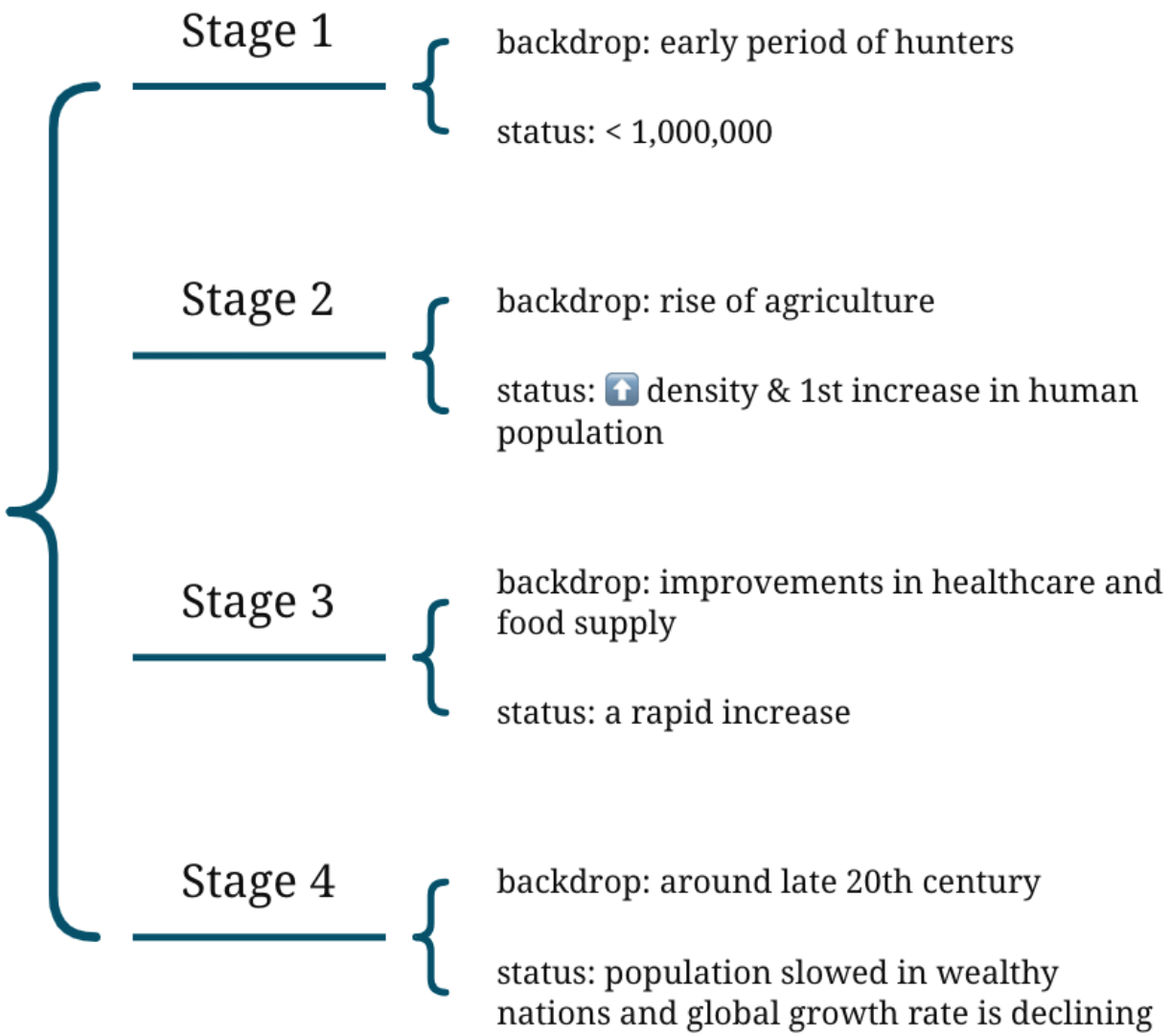
HUMAN POPULATION AND THE ENVIRONMENT

Video Time

2.1 The Human Population as an Exponential Growth Curve

We can divide the history of our species' population into four phases. In Stage 1, the early period of hunters and gatherers, the world's total human population was probably less than a few million. Stage 2 began with the rise of agriculture, which allowed a much greater density of people and the first major increase in the human population. Stage 3, the Industrial Revolution in the late 18th and early 19th centuries, saw improvements in health care and the food supply, which led to a rapid increase in the human population. The growth rate of the world's human population, like that of the early population of the United States, increased but varied during the first part of the 20th century, peaking in 1965–1970 at 2.1% because of improved health care and food production. Stage 4 began around the late 20th century. In this stage, population growth slowed in wealthy, industrialized nations, and although it has continued to increase rapidly in many poorer, less developed nations, globally the growth rate is declining and is now approximately 1.2%.

Phases of Human Population



2.2 Projecting Future Population growth

An exponentially growing population theoretically increases forever. However, on Earth, which is limited in size, this is not possible, as Thomas Henry Malthus pointed out in the 18th century. Eventually the population would run out of food and space and become increasingly vulnerable to catastrophes, as we are already beginning to observe. Consider, a population of 100 increasing at 5% per year would grow to 1 billion in less than 325 years. If the human population had increased at this rate since the beginning of recorded history, it would now exceed all the known matter in the universe. if a population cannot increase forever, what changes in the population can we expect over time? One of the first suggestions made about population growth is that it would follow a smooth S-shaped curve known as the logistic growth curve.

A logistic population would increase exponentially only temporarily. After that, the rate of growth would gradually decline (i.e., the population would increase more slowly) until an upper population limit, called the logistic carrying capacity, was reached. Once that had been reached, the population would remain at that number.

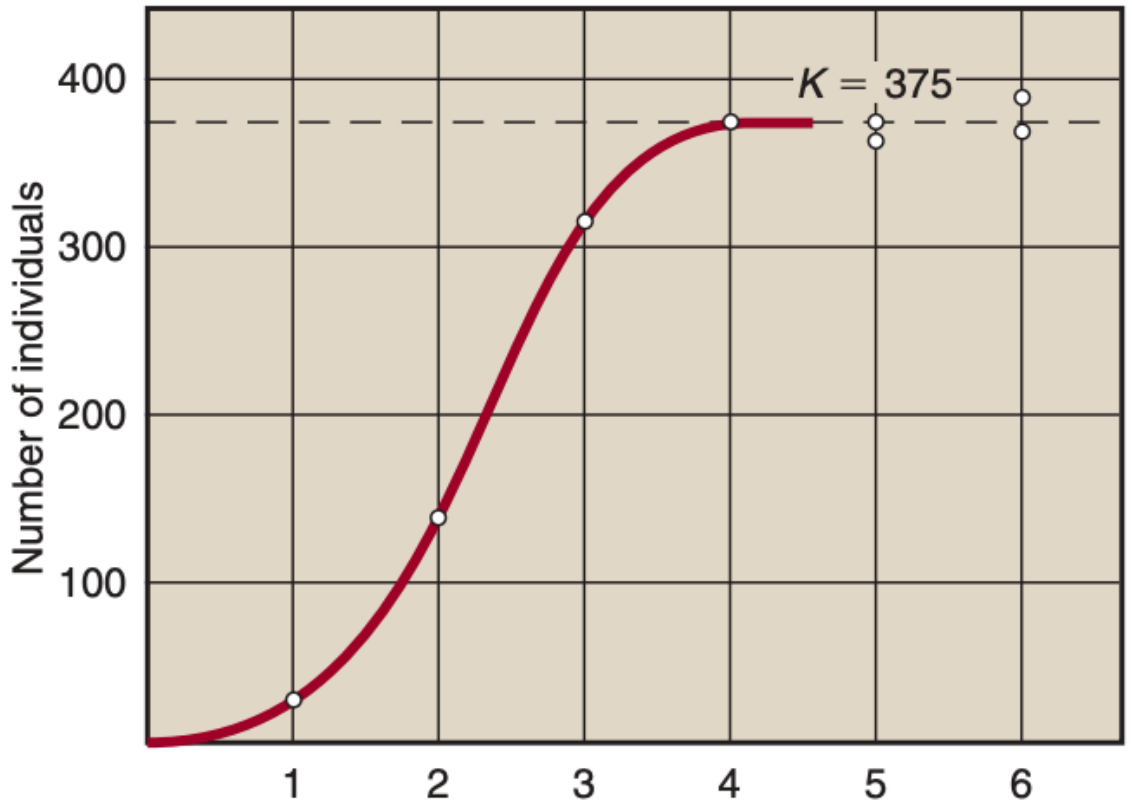
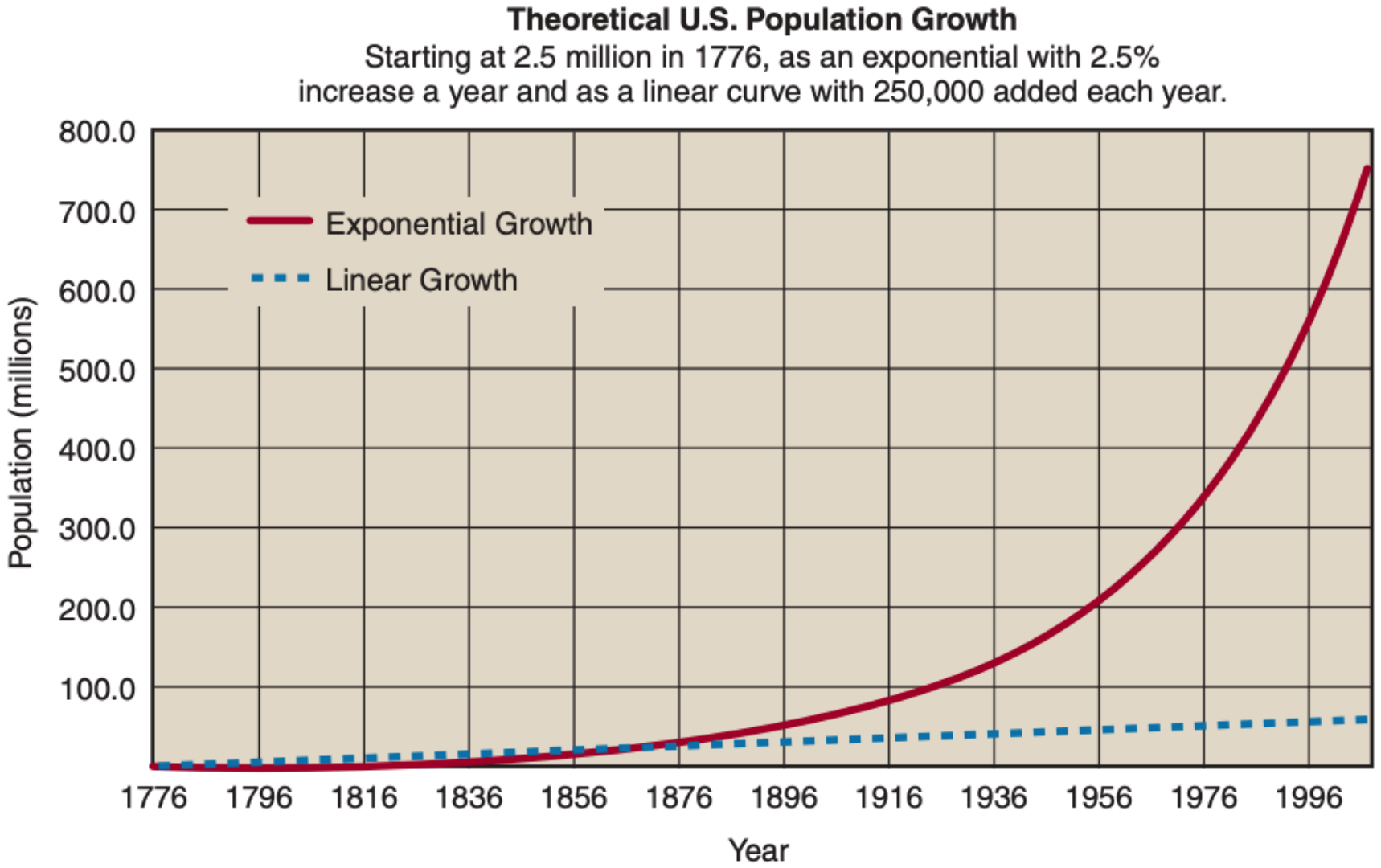


FIGURE 3.14 **(a) The logistic curve**. Growth of a population of a microorganism in a laboratory test tube under constant conditions with a constant supply of food. (From G.F. Gause, *The Struggle for Existence.*) The logistic carrying capacity is *k*. If you take a population of such bacteria into a laboratory and grow them under constant conditions, you might get the population to change according to the curve above, as Gause did in the 1930s with other microorganisms. (*Source:* D.B. Botkin, *Discordant Harmonies: A New Ecology for the 21st Century* [New York: Oxford University Press, 1990].)

Exponential and Logistic curve



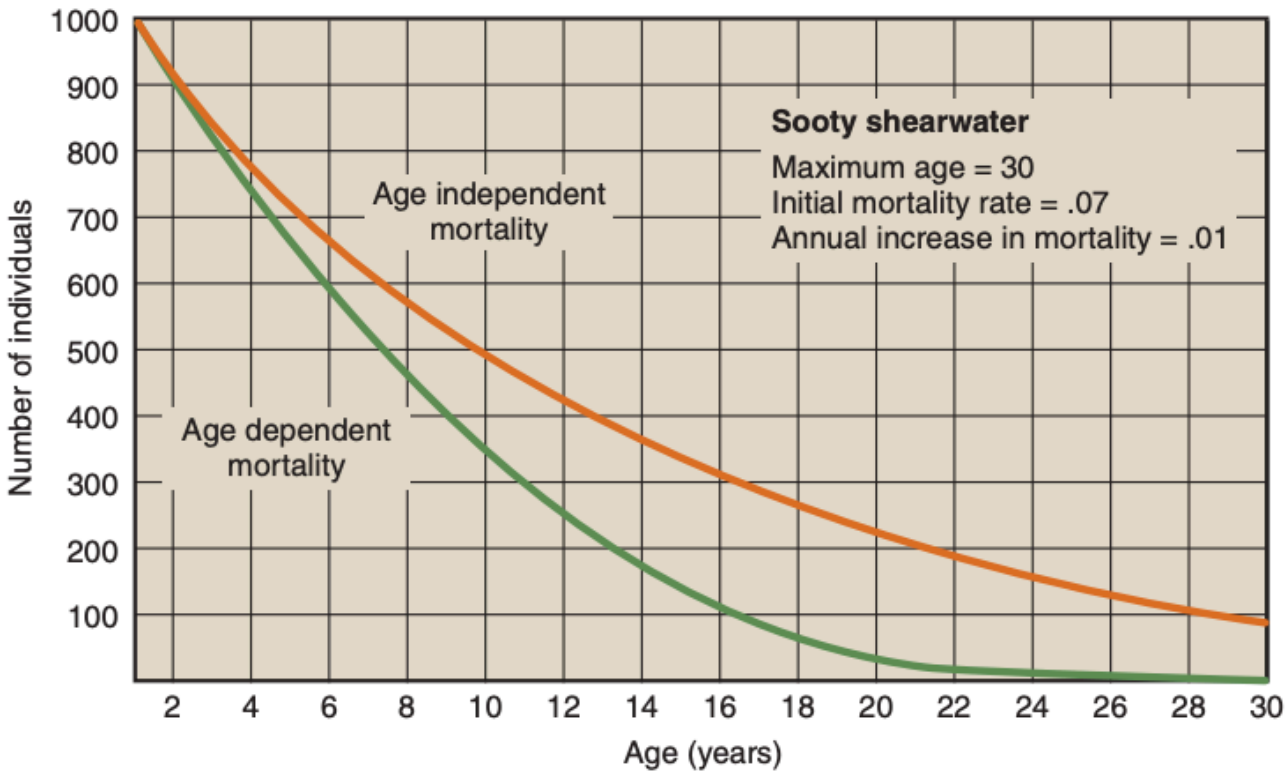
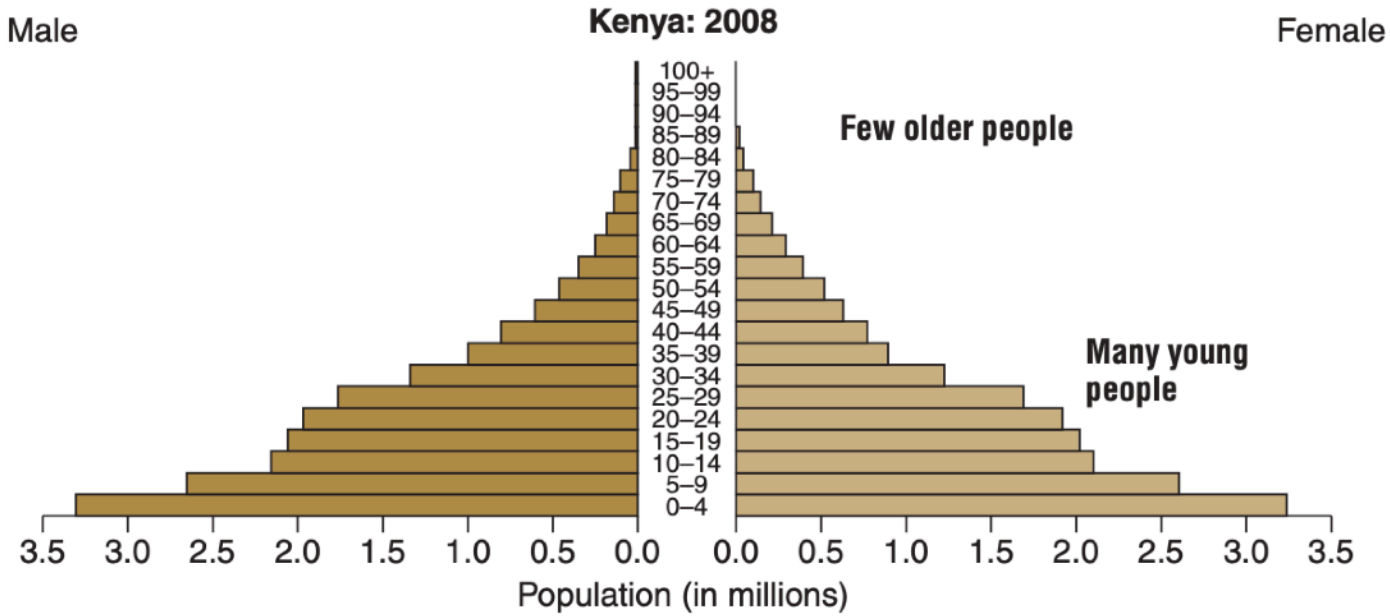
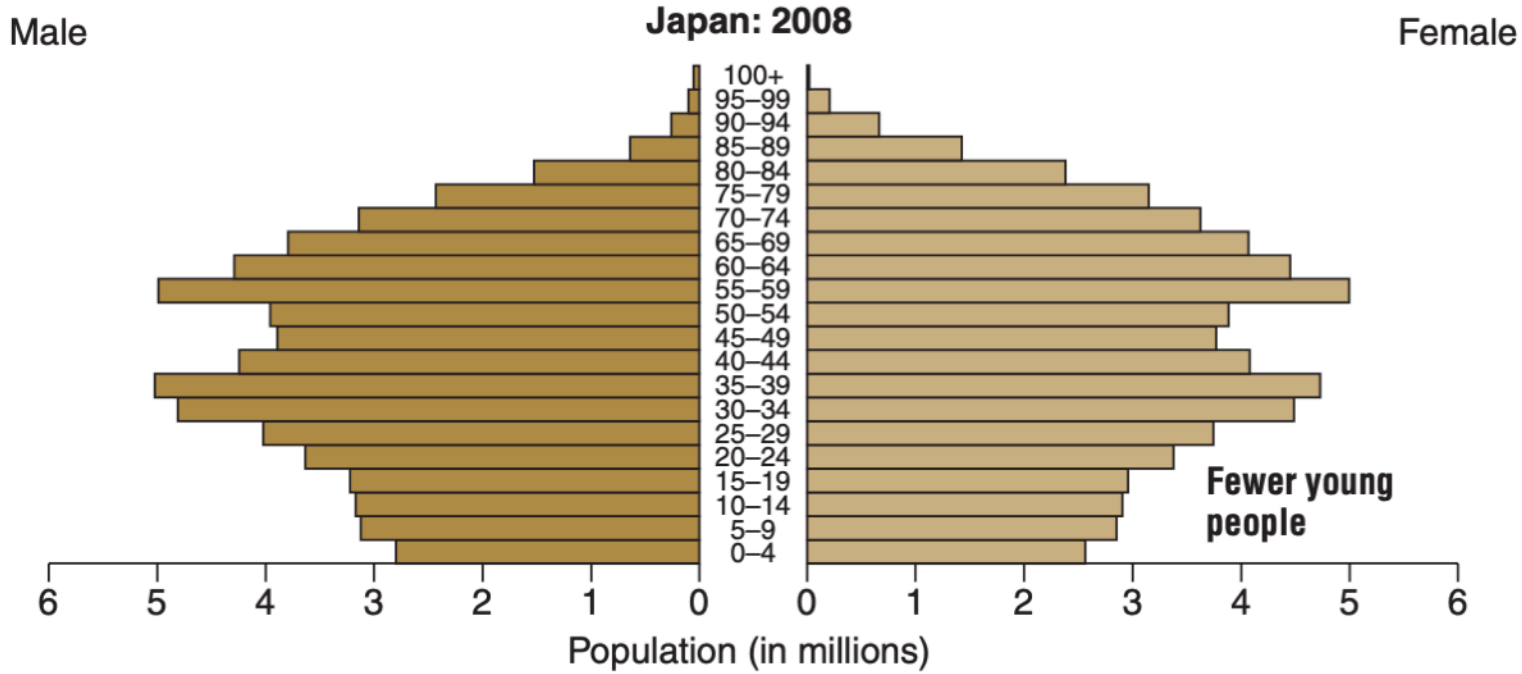


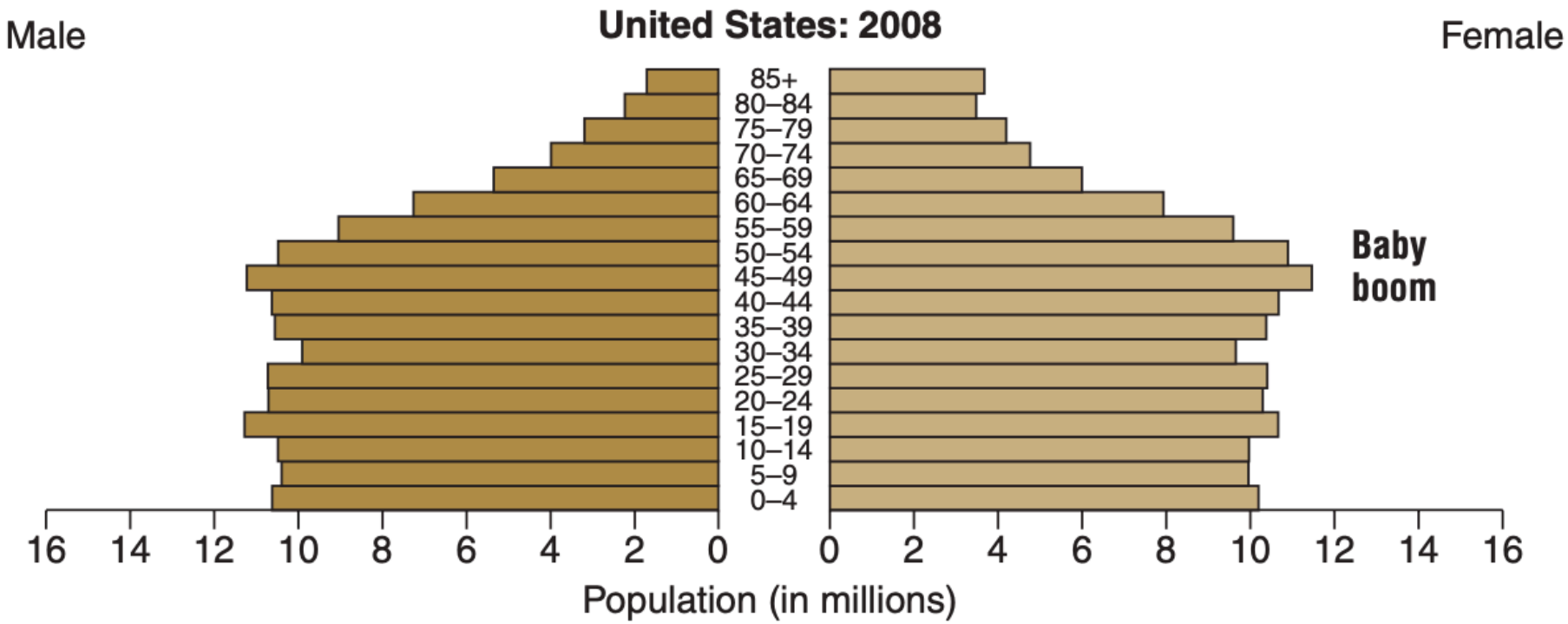
FIGURE 3.13 Negative exponential. Example: the decline in a population of a species of birds when there are no births and the mortality rate is 7% per year. The upper curve is a pure negative exponential. (*Source*: D.B. Botkin and R.S. Miller, 1974, Mortality rates and survival of birds, *American Nat.* 108: 181–192.)

The population age structure, which is the proportion of the population of each age group. The age structure of a population affects current and future birth rates, death rates, and growth rates; has an impact on the environment; and has implications for current and future social and economic conditions.

We can picture a population's age structure as a pile of blocks, one for each age group, with the size of each block representing the number of people in that group. Although age structures can take many shapes, four general types are most important to our discussion: a pyramid, a column, an inverted pyramid (top-heavy), and a column with a bulge. The pyramid age structure occurs in a population that has many young people and a high death rate at each age—and therefore a high birth rate, characteristic of a rapidly growing population and also of a population with a relatively short average lifetime. A column shape occurs where the birth rate and death rate are low and a high percentage of the population is elderly. A bulge occurs if some event in the past caused a high birth rate or death rate for some age group but not others. An inverted pyramid occurs when a population has more older than younger people.


Male
Kenya: 2008
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
Few older people
Many young people
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)


Male
Japan: 2008
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
Fewer young people
6 5 4 3 2 1 0
0 1 2 3 4 5 6
Population (in millions)



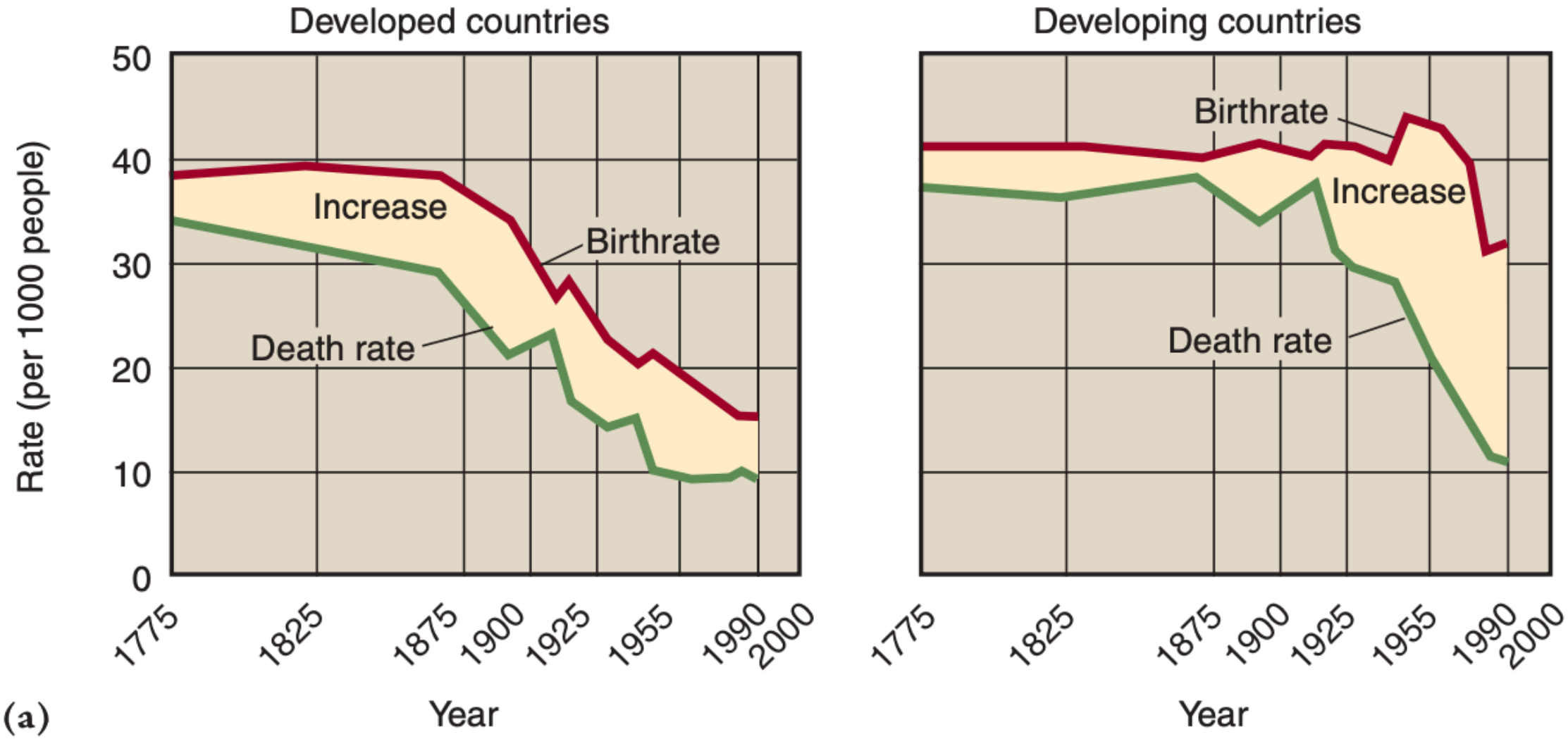
Source: U.S. Census Bureau, International Data Base.

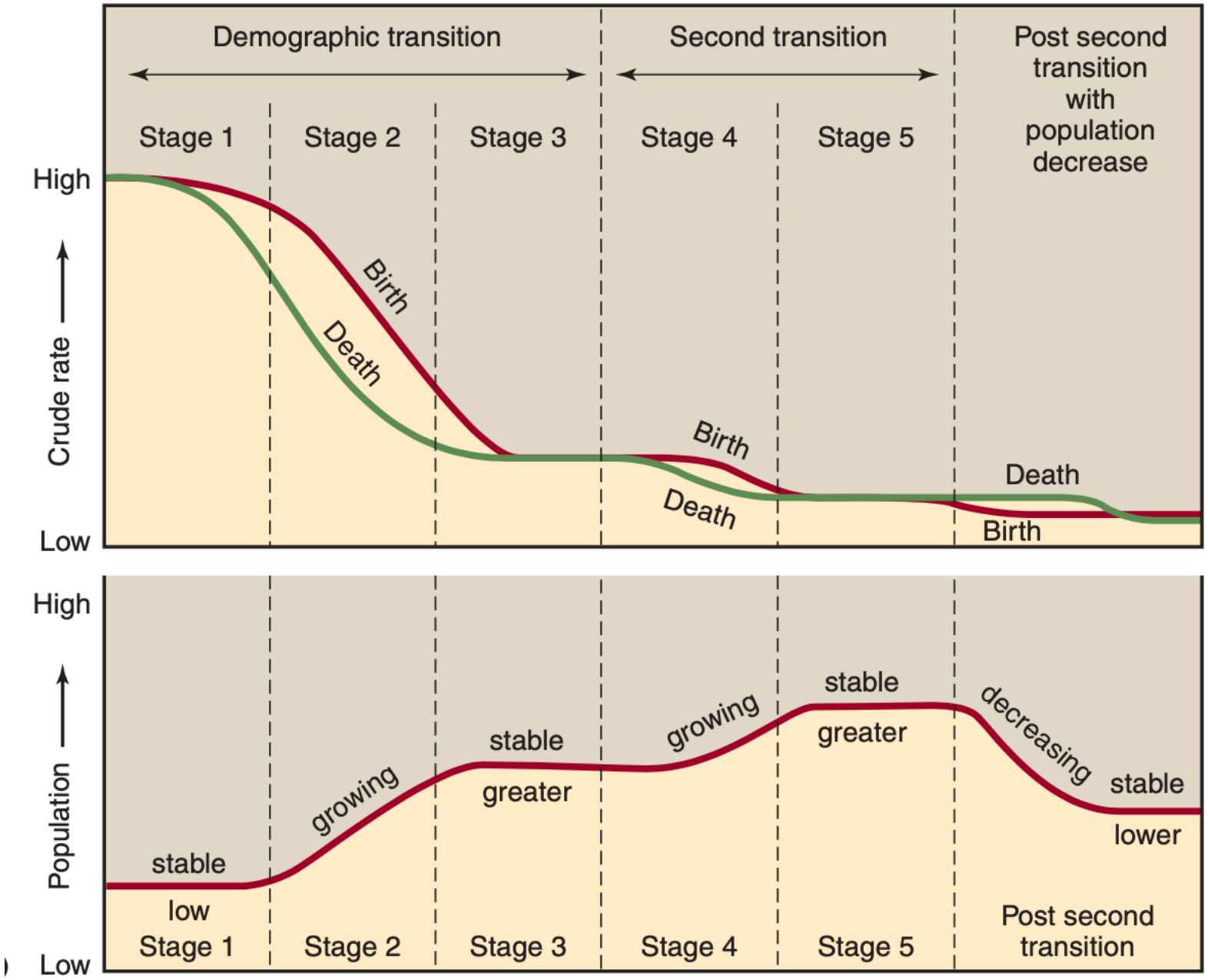
Video Time

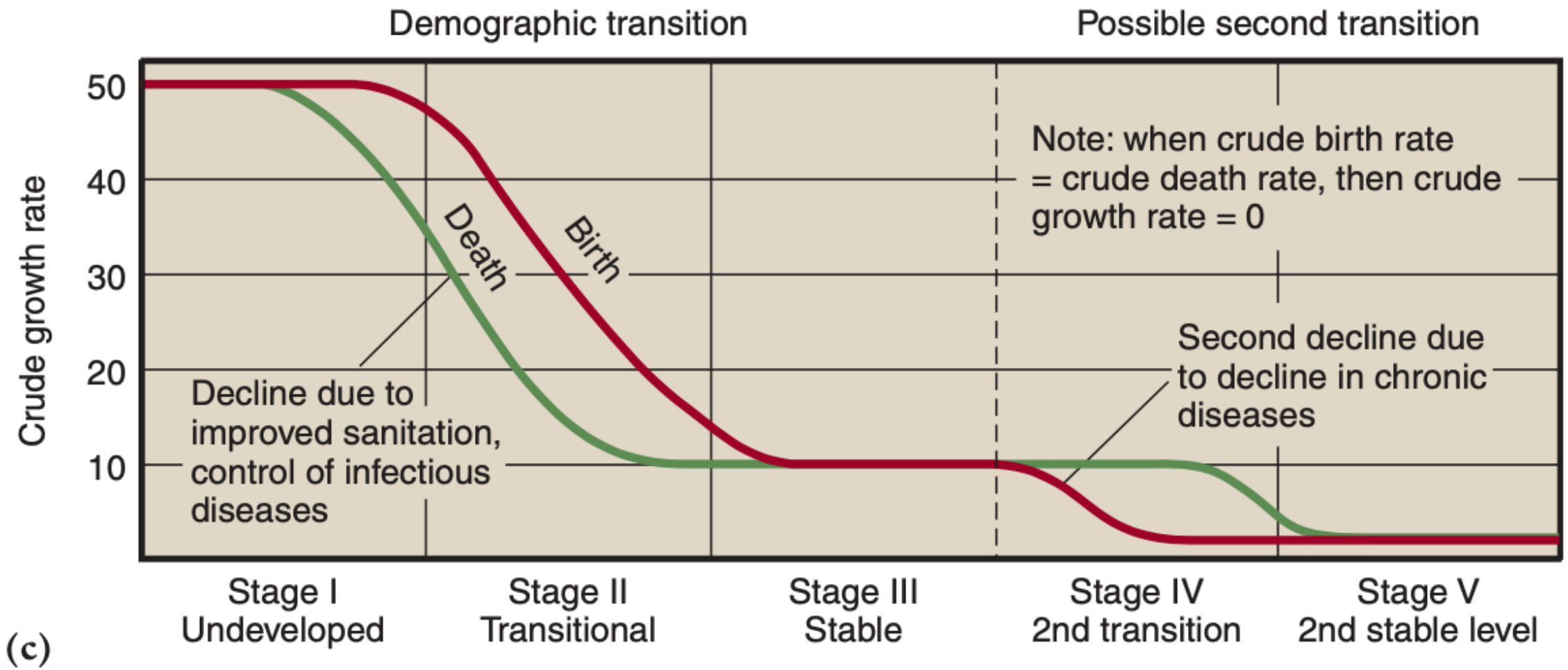
2.4 The Demographic Transition

There is a three-stage pattern of change in birth rates and death rates that has occurred during the process of industrial and economic development of Western nations. It leads to a decline in population growth.

A decline in the death rate is the first stage of the demographic transition. In a nonindustrial country, birth rates and death rates are high, and the growth rate is low. With industrialization, health and sanitation improve and the death rate drops rapidly. The birth rate remains high, however, and the population enters Stage II, a period with a high growth rate. Most European nations passed through this period in the 18th and 19th centuries. As education and the standard of living increase and as family-planning methods become more widely used, the population reaches Stage III. The birth rate drops toward the death rate, and the growth rate therefore declines, eventually to a low or zero growth rate. However, the birth rate declines only if families believe there is a direct connection between future economic well-being and funds spent on the education and care of their young. Such families have few children and put all their resources toward the education and well-being of those few.


Developed countries
Developing countries
Rate (per 1000 people)
50
40
30
20
10
0
Increase
Birthrate
Death rate
1775
1825
1875
1900
1925
1955
1990
2000
Year
(a)


Demographic transition
Second transition
Post second transition with population decrease
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
High
Crude rate
Low
Birth
Death
Birth
Death
Death
Birth
High
Population
Low
stable
low
growing
stable
greater
growing
stable
greater
decreasing
stable
lower
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Post second transition


Demographic transition
Possible second transition
Crude growth rate
50
40
30
20
10
Death
Birth
Note: when crude birth rate = crude death rate, then crude growth rate = 0
Second decline due to decline in chronic diseases
Decline due to improved sanitation, control of infectious diseases
Stage I Undeveloped
Stage II Transitional
Stage III Stable
Stage IV 2nd transition
Stage V 2nd stable level

(c)

2.5 The Human Carrying Capacity of Earth

What is the of Earth—that is, how many people can live on Earth at the same time? The answer depends on what quality of life people desire and are willing to accept.

As we have made clear in this chapter, on our finite planet the human population will eventually be limited by some factor or combination of factors. We can group limiting factors into those that affect a population during the year in which they become limiting (short-term factors), those whose effects are apparent after one year but before ten years (intermediate-term factors), and those whose effects are not apparent for ten years (long-term factors). Some factors fit into more than one category, having, say, both short-term and intermediate-term effects.

An important short-term factor is the disruption of food distribution in a country, commonly caused by drought or by a shortage of energy for transporting food.

Intermediate-term factors include desertification; dispersal of certain pollutants, such as toxic metals, into waters and fisheries; disruption in the supply of nonrenewable resources, such as rare metals used in making steel alloys for transportation machinery; and a decrease in the supply of firewood or other fuels for heating and cooking.

Long-term factors include soil erosion, a decline in groundwater supplies, and climate change. A decline in resources available per person suggests that we may already have exceeded Earth's long-term human carrying capacity.

THANK YOU