Population Biology

Biology 2201

Unit IV

Population Biology

- The study of populations is referred to as **demography**. The characteristics of populations usually studied are size, density and growth rate.

Important Terms

1) A ***population*** is a group of individuals of the same species that live in the same geographical area.

2) ***Population growth*** is the change in size of a population with time.

3) ***Population size*** is the number of individuals in a population.

4) ***Population density*** is the number of individuals per unit of volume or area.

Sampling Hare Populations

Lab p. 238-240 to be completed for June _______

Population Growth Patterns

Open and Closed populations

Ecologists classify populations as either open or closed.

In most natural ecosystems, four factors act on the population of each organism. These factors are:

A. **Natality**: The number of births, or offspring, born in one year.

B. **Mortality**: The number of deaths of individuals of a species in a year.

C. **Immigration**: The number of individuals of a species moving into an existing population.

D. **Emigration**: The number of individuals of a species moving out of an existing population.

A population is considered to be **open** if there is immigration and emigration. If immigration and emigration do not occur, as in lab settings or game reserves, then the population is considered to be **closed**.

The size of a population is limited by its **biotic potential**, known as the maximum number of offspring a species could produce, if resources were unlimited.

Four factors that determine biotic potential include:

A. Birth Potential: The maximum number of offspring per birth.

B. <u>Capacity for survival</u>: The number of offspring that reach reproductive age.

C. <u>Procreation</u>: The number of times that a species reproduces each year.

D. <u>Length of reproductive life</u>:Age of sexual maturity and the number of years capable to reproduce.

But, in nature, we know there are limits on the biotic potential of a population.

Limiting factors could include anything that is in short supply that would affect the size of the population.

Some examples of limiting factors are noted below:

	Factors Causing An Increase or Decrease in Population
Abiotic	Light, temperature, chemical environment
Biotic	Food availability, predators, disease and parasites, competition for resources

- Due to these biotic and abiotic factors, populations will fluctuate, but are generally considered to be stable, or in **equilibrium**.
- This stability of the population is related to the ***carrying capacity*** of the ecosystem.
- Carrying capacity is the maximum number of individuals of a species that can be supported indefinitely by an ecosystem.
- It is limited by the resources available, such as food and water.
- If a population exceeds its carrying capacity, it eventually must decline to below (or at) its carrying capacity, eventually regaining equilibrium again.

The size of a population is also controlled by two laws:

1. **The Law of Minimum**: The nutrient in least supply is the one that limits growth.

2. **The Law of Tolerance**: An organism can survive within (tolerate) a certain range of abiotic factors; above and below the limit it cannot survive. The greater the range of tolerance, the greater the organism's ability to survive.

- Some of the abiotic and biotic factors that influence population growth are themselves affected by the population's actual size, or **densisty**.
- These are called **density-dependent factors**.
- They affect the population because of the density of the population.
- Other factors that affect the population regardless of the population density are called density-independent factors.
- Here are some examples:

Density-dependent and Density-independent factors

Density-dependent factors	*Density-independent factors*
Food shortage Competition for mates Disease caused by a microorganism	Flood Fire Change in climate

Density-Dependent Factors

- These are the biotic factors that involve living things. Some example are:

1. Disease — close contact at high density; can spread by physical contact
2. Space and Stress — increases aggression in organisms due to lack of food, space etc.
3. Predation — interactions between predator and prey (predator - prey relationship)

Density-Dependant Factors

4. Competition — interspecific (different species) and intraspecific (same species)
5. Parasitism — a symbiotic relationships in which one organism benefits and harms another organism.
6. Food — competition for food among organisms
7. Environmental quality — the conditions affecting the habitat of organisms

Density-Independent Factors

- These are the abiotic (non-living) factors that affect populations regardless of their density.
- These factors can be : floods, droughts, forest fires, tornadoes, hurricanes, ice storms, earthquakes, human activities, clearing land for agriculture and lumber, etc.

Environmental quality – an explanation :

- Pollution is an unfavourable change in the environment. Here are some examples:

1. **Air pollution** — harmful particles released into the air

   a) photochemical smog (hydrocarbons and nitrous oxides react in strong sunlight) harmful to humans and plants with respiratory diseases

   b) Greenhouse effect increase CO_2 levels - also change moisture patterns

   c) acid rain caused by burning of fossil fuels

   - nitrogen and sulfur oxides dissolve on water vapour in atmosphere
   - dissolved oxides form nitric and sulfuric acid which fall to earth as rain damaging trees , killing fish ,and other organisms

2. Toxic chemicals

Produced from manufacturing processes

- a) release of ***toxins*** — non-biodegradable
- b) the problem of waste disposal

3. Water pollution

- Water pollution is the dumping of chemical pollutants into water

a) Algal Bloom (caused by fertilizers and sewage which cause an increase in algae growth)

b) pesticides (toxic chemicals — farm runoff)

c) Biological magnification — accumulation of pesticides into fatty tissue

4. Solid wastes

- Solid wastes generated by society (garbage)
- a) *incineration* (burning of garbage which releases toxic chemicals into the air)
- b) *ashes* (what remains after incineration is toxic)

Population Growth

- The size of a population changes due to **birth** and **immigration** (the movement of individuals into a population) and **death** and **emigration** (the movement of individuals out of a population).

- For example :
- - ***Birth rate*** is the rate at which reproduction adds new individuals. (eg.) 300 births into population of 10,000 Birth rate = 300/ 10,000 x 100 % or 3 %
- - ***Immigration*** is the movement of organism into a new area.
- - ***Death rate*** is the rate at which organisms die
- - ***Emigration*** is the movement of organisms out of an area.

Population Growth (word equation)

- Population Growth = (Births + Immigration) - (Deaths + Emmigration)

Important Terms

Biotic potential is the highest rate of reproduction possible under ideal conditions.

- For example, a house fly lays 100 eggs in which ½ of the flies are female that can reproduce after 1 month and then die. After 7 generations, there will be over 15 billion flies produced. But organisms do not reach their biotic potential because of such limiting factors as availability of food and space.

More terms

- The sum of all the limiting factors to prevent a population from reaching its biotic potential is called **environmental resistance**. It is the sum of the abiotic and biotic factors of a population’s environment.

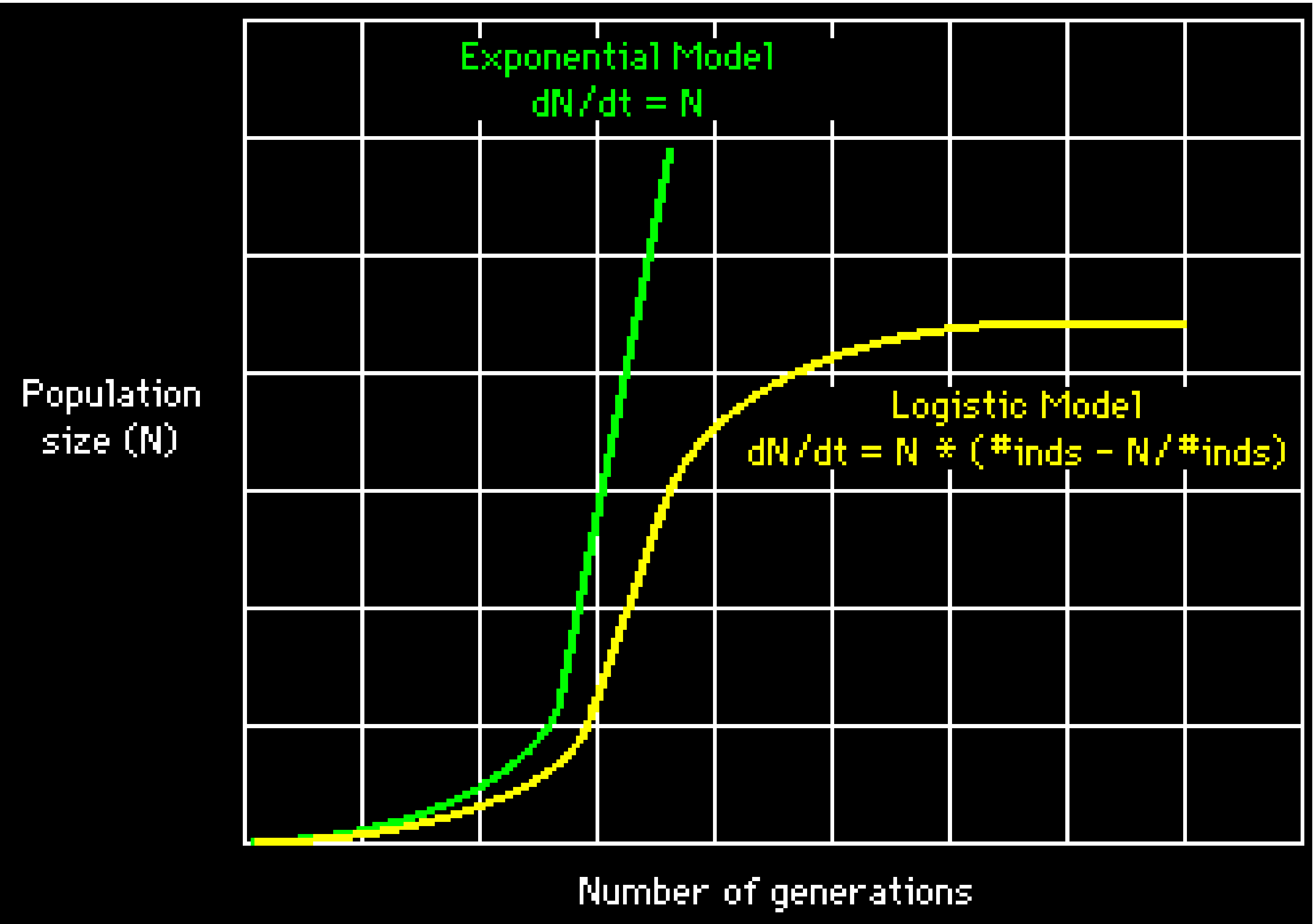
- ***Carrying capacity*** is the maximum population size that can be sustained in a given environmental resistance over a long period of time. It is the number of individuals that the environment can support indefinitely. It is related to the organisms position in food webs and energy pyramids.

Population Growth Rate Curves

- It is a graph of the rate of increase in size of a population with time.
- Examples of population growth curves:
- (A) exponential growth curve (J-shaped)
- (B) S-shaped or logistic curve
- (C) predator-prey relationship

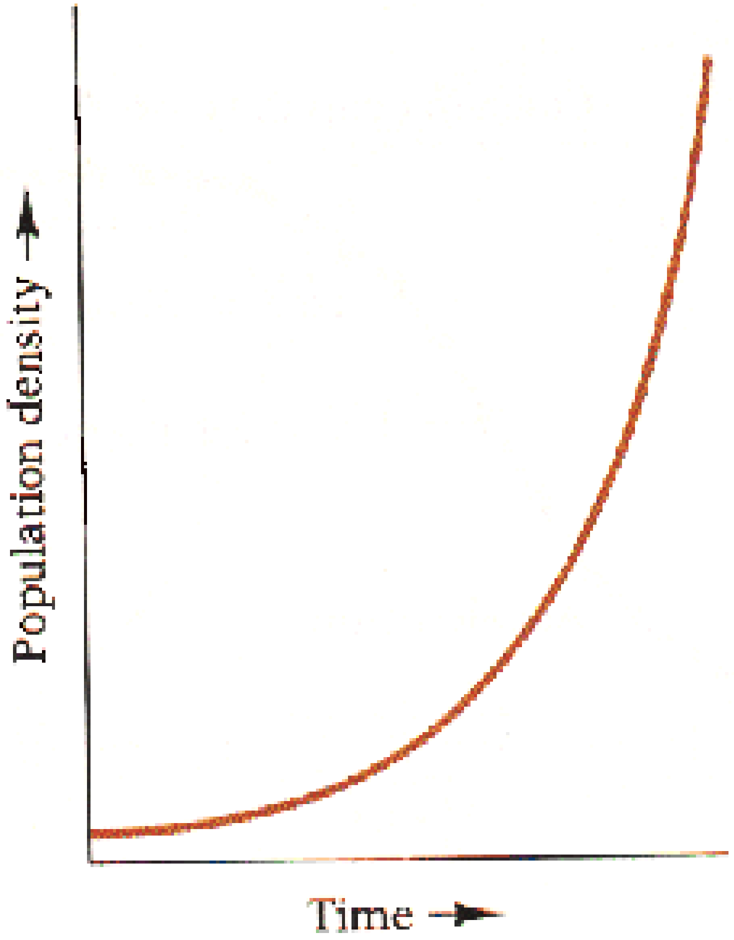
Typical population growth curves

Known as the J-shaped curve, it shows exponential growth of a population. An example is the human population.



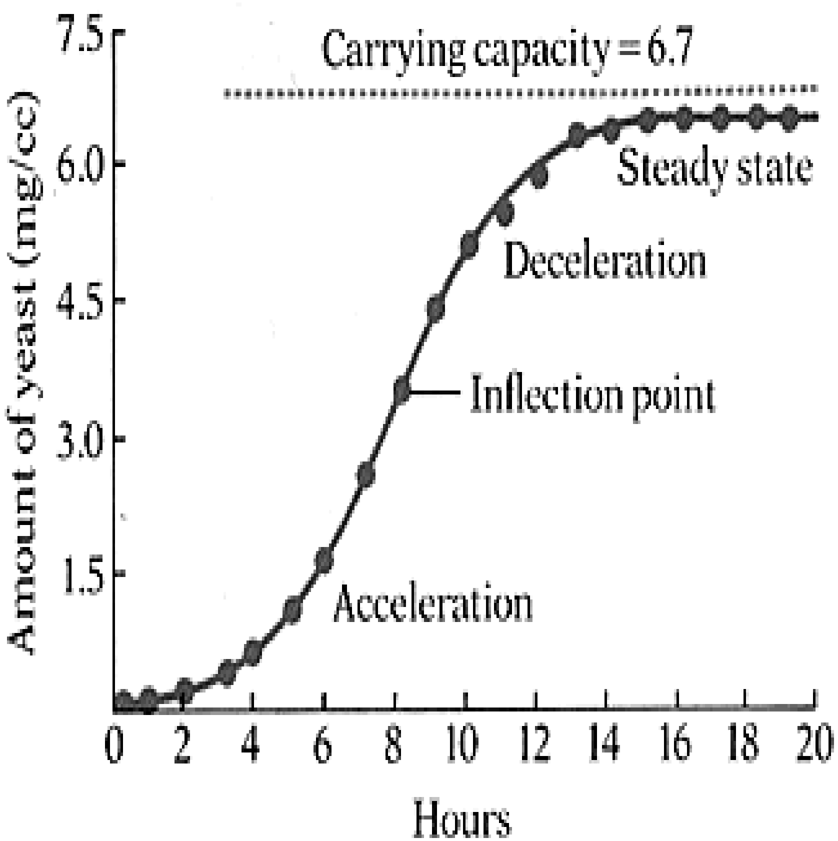
Known as the S-shaped (sigmoid) curve, it shows logarithmic growth of a population. The population has found its carrying capacity.

Exponential growth curve or J - shaped curve



- Is a graph of population size versus time that can be used to show population growth in an unlimited environment.
- A population if left unchecked would grow to an infinitely high number.
- The curve rises slowly at first (ie. Slow growth or lag phase) and then shoots up rapidly and keeps on going indefinitely (ie. Rapid growth or exponential phase).

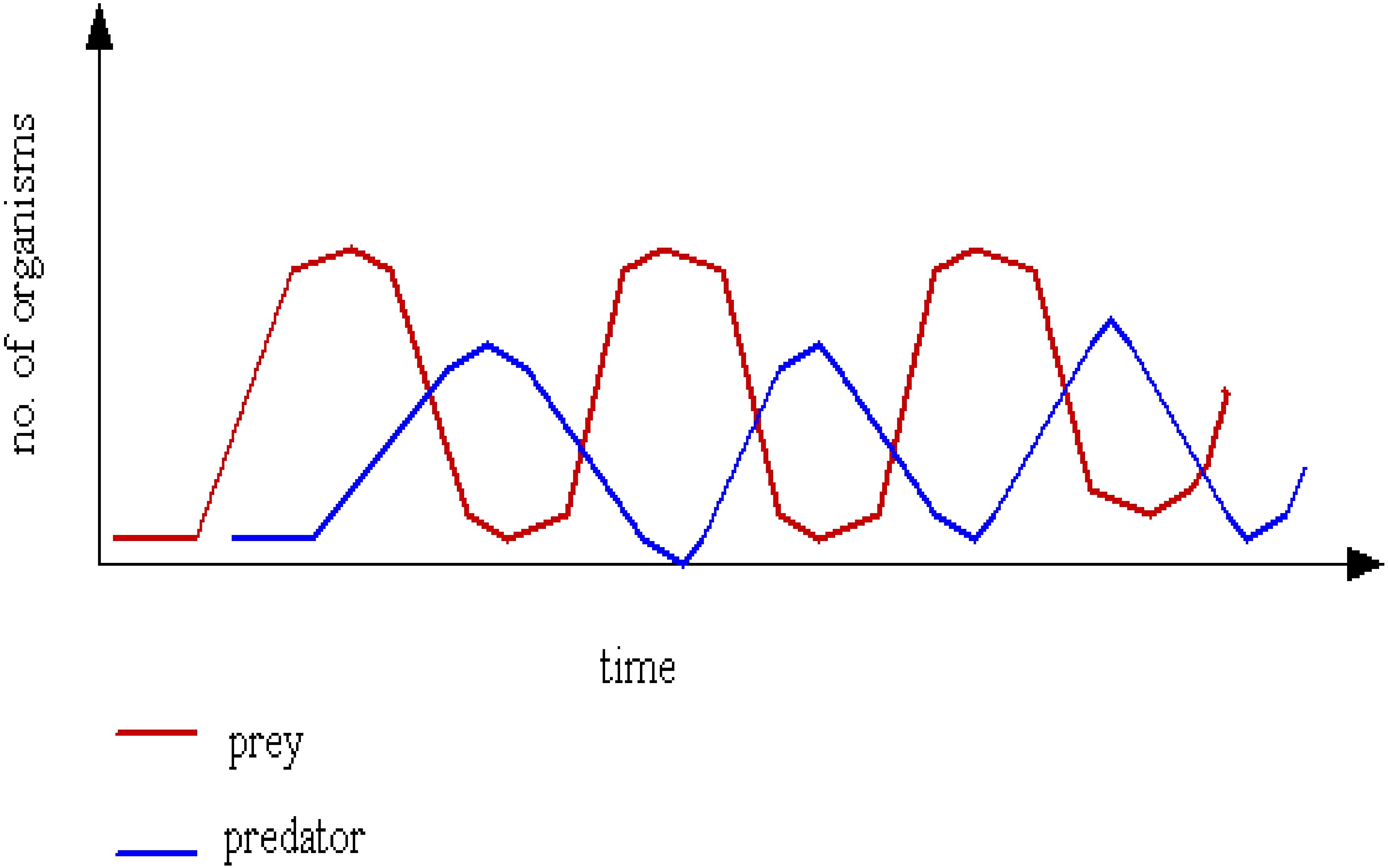
Logistic growth curve or S-shaped curve



- Is a graph of population size versus time that can show population change that occurs in limited environments.
- A population increases slowly at first (ie. slow growth or lag phase), rate of change increases quickly (ie. rapid growth or exponential phase), and eventually the population becomes so large that it stops growing altogether (ie. no growth or equilibrium phase — the birth rate and death rate are equal).

Predator-Prey relationship

- Is an example of a population cycle (ie. alternating periods of high and low populations).
- In this type of relationship, one population gains at the expense of the other. An example would be the Arctic hare and the Canada lynx as a predator-prey cycle.
- An increase in the hare population will decrease the competition for food amongst the lynx population.
- An increase in the predator (lynx) population will cause a decrease in the prey (hare) population. This decrease in the hare population will increase the competition for food in the lynx population and its population will in turn decrease.
- This decline in the predator population will permit the prey population (the hare) to increase in numbers again. The cycle continues.
- See Figure 7.37 on p. 237.


no. of organisms
time
prey
predator

Human Population Growth

- It should be noted that ***real populations*** grow exponentially for a short period of time until environmental resistance sets growth limits.
- For the ***human population***, it is presently growing at a very rapid rate.
- See Figure 8.2 on p. 257.
- The limiting factors today on world population would be such things as: the amount of space for populations, war, disease and poverty among populations.
- It is hard to estimate the overall carrying capacity of our planet due many factors.
- See Figure 8.13 on p. 270.

Earth Population

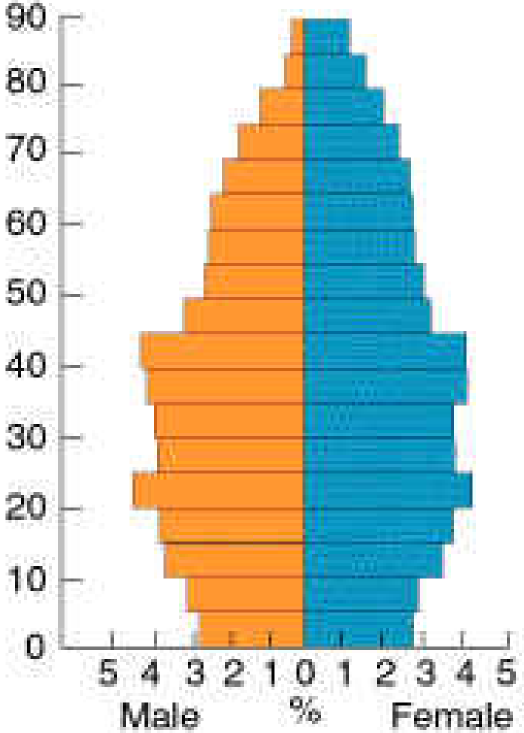
- For our planet Earth, there is an upper limit for population size that the earth can support.
- More industrialized nations have used technology to raise the carrying capacity of their environments.
- Less industrialized nations have reached or exceeded their carrying capacity for their environments.
- An increase in population growth puts stress on environmental life-support systems. We must curb or control, expanding global human population.

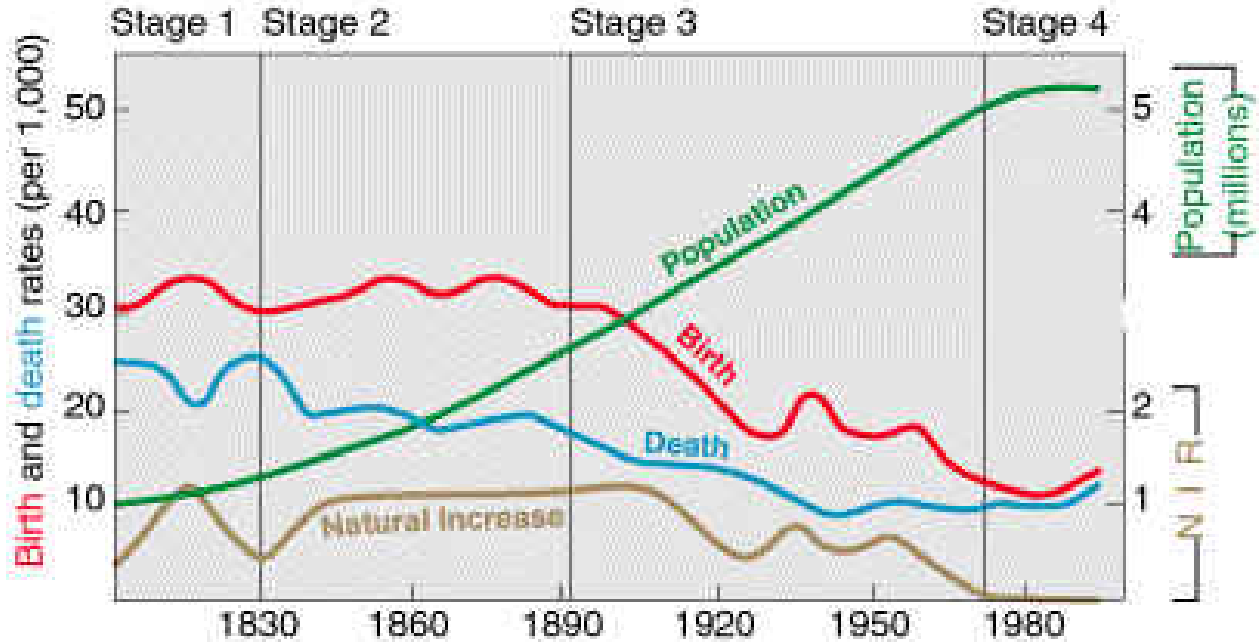
Effects of Industrialization

- **More industrialized nations** (or more developed nations) have an increased carrying capacity, but there is still a limit.
- ***Less industrialized nations*** (or less developed nations) have reached their carrying capacity due to depletion of water, soil, resources etc.

Demographic Transition

- It is a model put forth to explain the increases and decreases that occur in populations over time.
- It suggests that a population goes through a series of stages known as ***demographic transition***.
- It shows growth rate changes in relation to social and economic progress; (ie.) the gradual lowering of death and birth rates of a population.
- See Figure 8.3 on p. 257.


90
80
70
60
50
40
30
20
10
0
5 4 3 2 1 0 1 2 3 4 5
Male
%
Female


Stage 1
Stage 2
Stage 3
Stage 4
Birth and death rates (per 1,000)
Population (millions)
NIR
Population
Birth
Death
Natural Increase
50
40
30
20
10
5
4
2
1
1830
1860
1890
1920
1950
1980

STAGES :

- (1) BR and DR are high (especially in infants and children) which led to a slow population growth occurring in early human populations and some modern societies. The overall growth rate of a population is more or less stable.

- (2) The Industrial Revolution was changing the traditions of people. From it came improvements in living conditions such as nutrition, improvements in sanitation and medical care. This resulted in the DR being reduced and BR increasing; (ie.) BR > DR. The overall result was a period of rapid population growth.

- (3) Birth rates begin to decline due to a higher standard of living. This reduced DR (in infants) and the BR = DR (balanced or stabilize at a lower level) leads to the population size becoming more stable. This is known as ***zero population growth***.

- **NOTE :** (A) **More industrialized nations** — transition to the third stage ; OUR SOCIETY.
- (B) ***Less industrialized nations*** — in the second stage ; A DEMOGRAPHIC TRAP