Chapter 8
Understanding Populations
Section 1, How Populations Change in Size

DAY ONE
What Is a Population?

- A population is a group of organisms of the same species that live in a specific geographical area and interbreed.
- A population is a reproductive group because organisms usually breed with members of their own population.
- The word population refers to the group in general and also to the size of the population, or the number of individuals it contains.

7 Billion People Nat Geo
Properties of Populations

- **Density** is the number of individuals of the same species that live in a given unit of area.
- **Dispersion** is the pattern of distribution of organisms in a population.
- A population’s dispersion may be even, clumped, or random.
- Size, density, dispersion, and other properties can be used to describe populations and to predict changes within them.

*Population Density and Dispersion via YouTube*
How Does a Population Grow?

• A population gains individuals with each new offspring or birth and loses them with each death.

• The resulting population change over time can be represented by the equation below.

\[ \text{Change in population size} = \text{Births} - \text{Deaths} \]
How Does a Population Grow?

- **Growth rate** is an expression of the increase in the size of an organism or population over a given period of time.

\[
\text{Growth rate} = \frac{\text{change in population (birth rate – death rate)}}{\text{time}}
\]

- Overtime, the growth rates of populations change because birth rates and death rates **increase or decrease**.

- For this reason, growth rates can be positive, negative, or zero.
How Does a Population Grow?

• For the growth rate to be zero, the average number of births must equal the average number of deaths.

• A population would remain the same size if each pair of adults produced exactly two offspring, and each of those offspring survived to reproduce.

• If the adults in a population are not replaced by new births, the growth rate will be negative and the population will shrink.
How Fast Can a Population Grow?

- Populations usually stay about the same size from year to year because various factors kill many individuals before they can reproduce.

- These factors control the sizes of populations.

- In the long run, the factors also determine how the population evolves.
Reproductive Potential

• A species’ **biotic potential** is the fastest rate at which its populations can grow.

• This rate is limited by reproductive potential.

• **Reproductive potential** is the maximum number of offspring that a given organism can produce.

• Some species have much higher reproductive potentials than others.
  – Examples: Bacteria
Reproductive Potential

- Reproductive potential **increases** when individuals produce more offspring at a time, reproduce more often, and reproduce earlier in life.

- Reproducing earlier in life has the greatest effect on reproductive potential.

- Reproducing early **shortens** the generation time, or the average time it takes a member of the population to reach the age when it reproduces.
Reproductive Potential

- Small organisms, such as bacteria and insects, have short generation times and can reproduce when they are only a few hours or a few days old.
- As a result, their populations can grow quickly.
- In contrast, large organisms, such as elephants and humans, become sexually mature after a number of years and therefore have a much lower reproductive potential than insects.

Biotic Potential
Exponential Growth

- **Exponential growth** is logarithmic growth or growth in which numbers increase by a certain factor in each successive time period.

- Exponential growth occurs in nature only when populations have **plenty of food and space, and have no competition or predators**.

- For example, population explosions occur when bacteria or molds grow on a new source of food.
Exponential Growth

- In exponential growth, a large number of individuals is added to the population in each succeeding time period.
What Limits Population Growth?

• Because natural conditions are neither ideal nor constant, populations cannot grow forever.

• Eventually, resources are used up or the environment changes, and deaths increase or births decrease.

• Under the forces of **natural selection** in a given environment, only some members of any population will survive and reproduce. Thus, the properties of a population may change over time.
Carrying Capacity

- **Carrying capacity** is the largest population that an environment can support at any given time.
- A population may increase beyond this number but it cannot stay at this increased size.
- Because ecosystems change, carrying capacity is difficult to predict or calculate exactly.
- However, it may be estimated by looking at average population sizes or by observing a population crash after a certain size has been exceeded.
Carrying Capacity

- Population overshots carrying capacity
- Population runs out of resources and declines
- Population recovers and stabilizes
- Population crashes

Diagram shows the relationship between population size and time, illustrating the concept of carrying capacity.
Resource Limits

• A species reaches its carrying capacity when it **consumes** a particular natural resource at the same rate at which the ecosystem produces the resource.

• That natural resource is then called a **limiting resource**.

• The supply of the most **severely** limited resources determines the carrying capacity of an environment for a particular species at a particular time.
Competition Within a Population

- The members of a population use the same resources in the same ways, so they will eventually compete with one another as the population approaches its carrying capacity.

- Instead of competing for a limiting resource, members of a species may compete indirectly for social dominance or for a territory.

- Competition within a population is part of the pressure of natural selection.
Competition Within a Population

- A **territory** is an area defended by one or more individuals against other individuals.

- The territory is of value not only for the **space** but for the **shelter, food, or breeding sites** it contains.

- Many organisms expend a large amount of time and energy competing with members of the same species for mates, food, or homes for their families.
Two Types of Population Regulation

• Population size can be limited in ways that may or may not depend on the density of the population.

• Causes of death in a population may be density dependent or density independent.
Population Regulation

• When a cause of death in a population is density dependent, deaths occur more quickly in a crowded population than in a sparse population.

• This type of regulation happens when individuals of a population are densely packed together.

• **Limited resources, predation and disease** result in higher rates of death in dense populations than in sparse populations.
Population Regulation

• When a cause of death is density independent, a certain proportion of a population may die regardless of the population’s density.

• This type of regulation affects all populations in a general or uniform way.

• Severe weather and natural disasters are often density independent causes of death.
Ticket out the Door

• What is a population?
• What is density?
• What is dispersion?
• What is the equation for calculating a population size?
• What is growth rate (an equation would be good also)?
• What is carrying capacity?
Chapter 8
Understanding Populations
Section 2: How Species Interact With Each Other

DAY ONE
An Organism’s Niche

• A niche is the unique position occupied by a species, both in terms of its physical use of its habitat and its function within an ecological community.

• A niche is different from a habitat. An organism’s habitat is a location. However, a niche is an organism’s pattern of use of its habitat.

• A niche can also be thought of as the functional role, or job of a particular species in an ecosystem.
Symbiosis and Coevolution

- **Symbiosis** is a relationship in which two different organisms live in close association with each other.
- Symbiosis is most often used to describe a relationship in which **at least one species benefits**.
- Overtime, species in close relationships may **coevolve**.
- These species may evolve adaptations that **reduce the harm or improve the benefit** of the relationship.
Ways in Which Species Interact

- Interactions between species are categorized at the level where one population interacts with another.
- The five major types of species interactions are:
  - Competition
  - Predation
  - Parasitism
  - Mutualism
  - Commensalism
Species Interactions

Types of Interactions Between Two Species

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Species A</th>
<th>Species B</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>harmed</td>
<td>harmed</td>
<td>Each species negatively affects the other.</td>
</tr>
<tr>
<td>Predation and parasitism</td>
<td>benefited</td>
<td>harmed</td>
<td>Species A feeds on species B.</td>
</tr>
<tr>
<td>Mutualism</td>
<td>benefited</td>
<td>benefited</td>
<td>Each species is helpful to the other.</td>
</tr>
<tr>
<td>Commensalism</td>
<td>benefited</td>
<td>unaffected</td>
<td>Species A benefits from species B, but B is unaffected.</td>
</tr>
</tbody>
</table>

COMMENSALISM Wren makes nest without affecting cactus

MUTUALISM Yucca moth pollinates and lays eggs on yucca flowers; moth larvae spread yucca seeds

PREDATION Kit fox hunts and feeds on kangaroo rat

COMPETITION Fox and coyote are predators of same prey
Ways in Which Species Interact

- These categories are based on whether each species causes benefit or harm to the other species in a given relationships in terms of total effects over time.
- Other types of interactions are possible.
- Many interactions between species are indirect, some interactions do not fit in a category clearly, and other types seem possible but are rarely found.
- Therefore, many interactions are neither categorized nor well studied.
Competition

• **Competition** is the relationship between two species (or individuals) in which both species (or individuals) attempt to use the same limited resource such that both are negatively affected by the relationship.

• Members of the same species must compete with each other because they require the same resources because they occupy the same niche.

• When members of different species compete, we say that their niches overlap, which means that each species uses some of the same resources in a habitat.
Indirect Competition

• Species can compete even if they never come into direct contact with each other.

• For example, suppose that one insect feeds on a certain plant during the day and that another species feeds on the same plant during the night.

• Because they use the same food source, the two species are **indirect competitors**.

• Humans rarely interact with the insects that eat our food crops, but those insects are still competing with us for food.
Adaptations to Competition

• When two species with similar niches are placed together in the same ecosystem, we might expect one species to be more successful than the other.

• But in the course of evolution, adaptations that decrease competition will also be advantageous for species whose niches overlap.

• One way competition can be reduced between species is by dividing up the niche in time or space.
Adaptations to Competition

Niche restriction is when each species uses less of the niche than they are capable of using.

It is observed in closely related species that use the same resources within a habitat.

For example, *Chthamalus stellatus*, a barnacle species, is found only in the upper level of the intertidal zone when another barnacle species is present.

When the other species is removed, *C. stellatus* can be found at deeper levels.

The actual niche used by a species may be smaller than the potential niche.
Adaptations to Competition

Chthamalus niche size when competition is present

Chthamalus stellatus

Semibalanus balanoides

HIGH TIDE

LOW TIDE
Predation

- **Predation** is an interaction between two species in which one species, the predator, feeds on the other species, the prey.

- In complex food webs, a predator may also be the prey of another species.

- Most organisms have evolved some mechanisms to avoid or defend against predators.
Predators

- Some predators eat only specific types of prey.
- In this kind of close relationship, the sizes of each population tend to increase and decrease in linked patterns, as shown below.
Parasitism

- An organism that lives in or on another organism and feeds on the other organism is a **parasite**.
  - Examples include ticks, fleas, tapeworms, heartworms, and bloodsucking leeches.
- The organism, the parasite, takes its nourishment from is known as the **host**.
- **Parasitism** is a relationship between two species, the parasite, benefits from the other species, the host, and usually harms the host.
Parasitism

- The differences between a parasite and a predator are that a parasite spends some of its life **in or on** the host, and that the parasites do not usually kill their hosts.
- In fact, the parasite has an evolutionary advantage if it allows its host to live longer.
- However, the host is often weakened or exposed to disease by the parasite.
Mutualism

- Many species depend on another species for survival. In some cases, neither organism can survive alone.

- **Mutualism** is a relationship between two species in which both species benefit.

- Certain species of bacteria in your intestines form a mutualistic relationship with you.

- These bacteria help break down food that you cannot digest. In return, you give the bacteria a warm, food-rich habitat.
Commensalism

- **Commensalism** is a relationship between two organisms in which one organism benefits and the other in unaffected.
- An example is the relationship between sharks and a type of fish called remoras.
- Remoras attach themselves to sharks and feed on scraps of food left over from the shark’s meals.
- Even seemingly harmless activity, however, might have an effect on another species.
Symbiosis via YouTube

Untamed Science Explains Symbiosis
Symbiosis Song – Something to Help You Remember

Symbiosis Song
Ticket Out the Door

• What is the difference between a niche and a habitat?
• What is symbiosis?
• What is competition?
• What is predation?
• What is mutualism?
• What is parasitism?
• What is commensalism?