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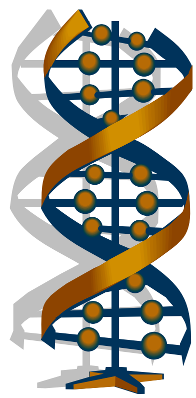

Grade 12, University Preparation Biology

Unit 5: Population Dynamics

Unit 5: Population Dynamics

Introduction

"World population recently reached 6 billion. It took only twelve years to add the last billion, the shortest such span in history. By 2025, we can expect a further 2 billion - almost all in developing countries, and most of them the poorest. We must act now."
- United Nations Secretary General Kofi Annan

With the world population currently over 6.5 billion people and its doubling time occurring in under 50 years, most people are concerned about what this means for our planet. In order to understand what the future holds, one must have an understanding of population dynamics.

In this unit, you will learn about the characteristics of populations and ways in which populations interact with one another. You will also learn ways to estimate populations and calculate population growth. You will examine the factors affecting human population growth, paying particular attention to the impact of exponential human growth on the environment and how it contributes to our overall ecological footprint.

Overall Expectations:

- analyse the relationships between population growth, personal consumption, technological development, and our ecological footprint, and assess the effectiveness of some Canadian initiatives intended to assist expanding populations
- investigate the characteristics of population growth, and use models to calculate the growth of populations within an ecosystem
- demonstrate an understanding of concepts related to population growth, and explain the factors that affect the growth of various populations of species

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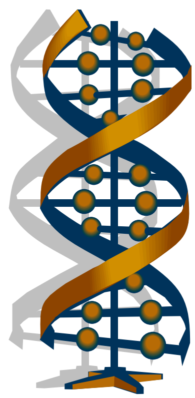

Grade 12, University Preparation Biology

Lesson 17 – Community Interactions

Lesson 17: Community Interactions

Ecology is the study of the relationships between organisms and their environments. It involves interactions between both the living, biotic, and non-living, abiotic, components within the environment. Biotic components of the environment involve all living things and how they interact with the population. While abiotic components can include factors such as light, water, and soil.

In this lesson, you will look at factors that cause changes in populations with a detailed look at density-dependent and density independent factors.

What You Will Learn

- explain how a change in one population in an aquatic or terrestrial ecosystem can affect the entire hierarchy of living things in that system
- explain the concepts of interaction (e.g., competition, predation, defence mechanism, symbiotic relationship, parasitic relationship) between different species
- explain factors such as carrying capacity, fecundity, density, and predation that cause fluctuation in populations, and analyse the fluctuation in the population of a species of plant, wild animal, or microorganism
- describe factors that affect population change

Interactions within Communities

Organisms usually stay together in groups with members of the same species. This is called a **population** and is generally restricted to a specific area. Populations will interact with populations of different species within a **community**. Some organisms within communities cannot exist independently of one another and work together for survival. For example, some flowering plants rely on insects to pollinate them so that they can reproduce. All the members of a community plus the abiotic factors influencing them make up an **ecosystem**.

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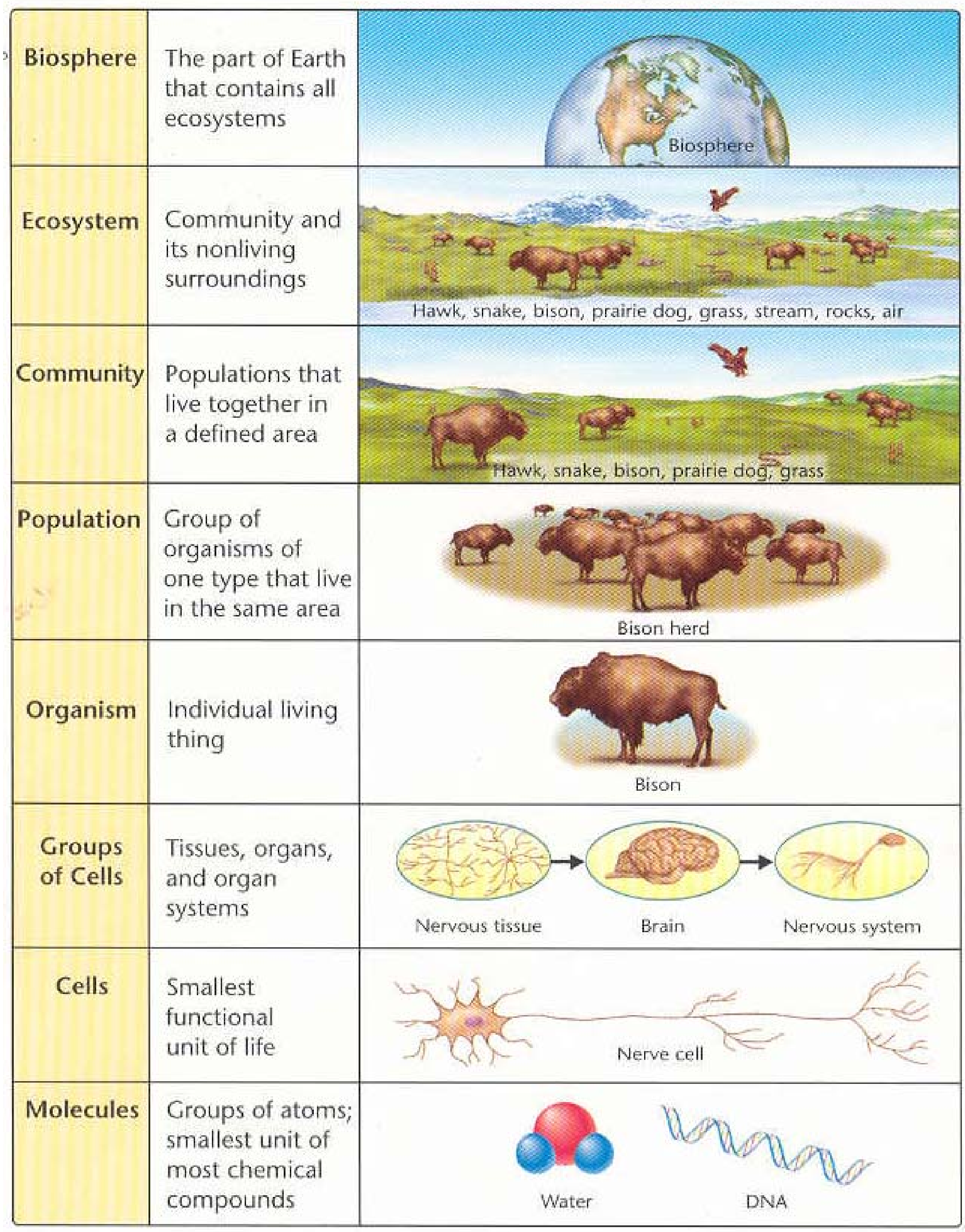
Levels of Organization



Biosphere	The part of Earth that contains all ecosystems	Biosphere
Ecosystem	Community and its nonliving surroundings	Hawk, snake, bison, prairie dog, grass, stream, rocks, air
Community	Populations that live together in a defined area	Hawk, snake, bison, prairie dog, grass
Population	Group of organisms of one type that live in the same area	Bison herd
Organism	Individual living thing	Bison
Groups of Cells	Tissues, organs, and organ systems	Nervous tissue → Brain → Nervous system
Cells	Smallest functional unit of life	Nerve cell
Molecules	Groups of atoms; smallest unit of most chemical compounds	Water, DNA

Figure1: Levels of Organization

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Ecological Niches
Animals either adapt constantly to changes in their community or survive by occupying an ecological niche. An ecological niche is the place or function of a given organism within its ecosystem. It includes a set of biological characteristics that includes the use and interaction with abiotic and biotic resources.

Habitat = address   Ecological Niche = occupation

Fundamental Niche
The fundamental niche is the biological characteristics of the organism and the resources in the environment that a population can theoretically use under ideal conditions, i.e. when there is no competition and abundant resources.

Realized Niche
This is the biological characteristics of the organism and the resources in the environment that a population actually does use due to competition.

Analogy:
You are capable of becoming the next Canadian Idol winner (fundamental niche), but fierce competition from others may mean that you only become runner-up (realized niche)!

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

1. Differentiate between ecological, fundamental and realized niche.

2. Place the terms: organism, ecosystem, community, population in order from smallest to largest in terms of quantity of individuals.

Factors Affecting Population Changes

Intraspecific competition occurs when individuals within the same population rely on the same resource for survival and are competing for it.

Density – Dependent Factors influence population regulation and have a greater impact as population density increases or decreases. The following are some examples of density-dependent factors:

1. **Intraspecific Competition**
    - Individuals of the same species/population compete for resources in their habitat. i.e. stronger animals will survive and weaker ones will die.

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2. **Predation**
    - Consumption of prey by predators or carnivores (usually a member of another species)
3. **Disease**
    - In dense, over-crowded populations, pathogens pass from host to host with greater ease because there are more hosts available in close proximity to one another.
4. **Allee Effect**
    - In small populations, it is often difficult for individuals to find mates. i.e. extinction of passenger pigeon

When there is a small population, inbreeding results leading to the loss of genetic variation. The smallest number of individuals that ensures that the population can persist for a determined interval of time is referred to as the **minimum viable population size**. The minimum viable population size varies among species and it is used to help estimate "at risk" populations.

Density-Independent Factors influence population regulation regardless of the population density. For example, population growth is limited by human intervention through things such as the use of insecticides. Extreme weather changes in environmental conditions can limit some organisms that are unable to breed in extreme temperatures.

Limiting factors prevent populations from achieving their biotic potential, or carrying capacity. A limiting factor is any essential resource that is in short supply or is unavailable and may be abiotic or biotic. For example, shortages of light, food/prey, space, water, or nutrients can all be limiting factors. **Carrying Capacity** is the maximum number of organisms that can be sustained by the resources available over a specified time period.

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

3. Differentiate between density-dependent and density-independent factors.

4. Identify the following as either density-dependent or density-independent:

    a. intraspecfic competition
    b. human interference
    c. a hurricane
    d. disease

5. What would be some limiting factors for a tree growing in the rainforest?

Classification of Interactions between 2 species

Table 1: Classification of Interactions

Interaction		Effect on Population
Competition		Interaction may be detrimental to one or both species
Predation		Interaction is beneficial to one species and usually lethal to the other
Symbiosis	• Parasitism	Interaction is beneficial to one species, and harmful, but not usually fatal to the other
	• Mutualism	Interaction is beneficial to both species
	• Commensalism	Interaction is beneficial to one species and the other species is unaffected

Competition

Interspecifc competition occurs between individuals of different species competing for an essential common resource that is limited in supply. It limits population growth and can occur in two ways:

- Interference: actual fighting over resources. i.e. tree swallows and bluebirds over bird houses
- Exploitative competition: consumption or use of shared resources. i.e. arctic foxes and snowy owls prey on the arctic hare.

The strongest competition occurs between populations of species that experience a niche overlap.

Results of Interspecific Competition

- Population size of the weaker competitor decreases
- One species changes its behaviour and survives using different resources
- One population could migrate where there are more resources

All of the above would reduce competition.

Sometimes species occupying the same niche avoid or reduce competition for similar resources by a process called **resource partitioning**. This means that each organism uses a different part of the habitat. Example;

- Some animals that share common food needs which may avoid competition by occupying different sections of their habitat. Some live on the leaf litter floor while others live on shady branches, thereby avoiding competition over food.
- Some plants have roots that go to different levels within the soil, thereby capturing nutrients from different regions and reducing competition amongst nearby plants.

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Interspecific Competition forces populations to evolve adaptations that enable them to use resources for continued survival. If they do not, then they perish.

Predation

Predation is an example of interspecific interaction in which the population density of one species (the predator) increases while the population density of the other species (the prey) declines.

Effects on the size of predator and prey populations (there will be a lag between these responses)

increase prey ⟶ increase food for predators ⟶ increase predator population

increase predator population ⟶ decrease prey ⟶ decrease predator population

The graph below shows the predator and prey cycles between a moose and wolf population.

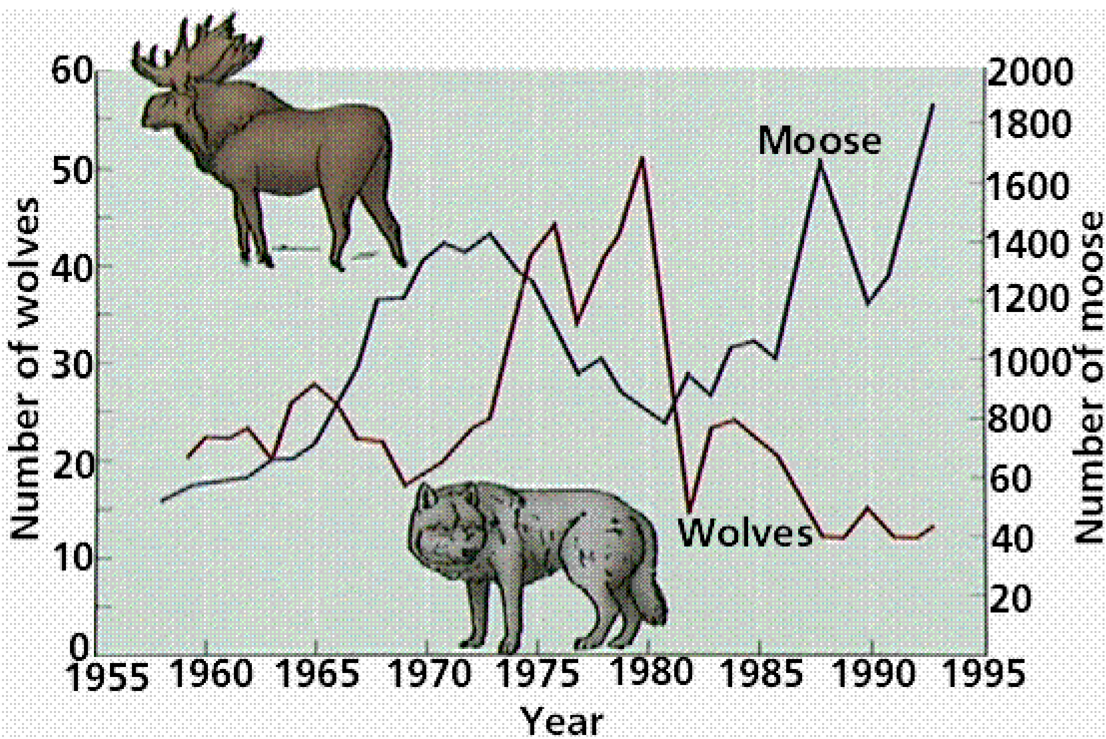

Figure 2: Predator and Prey

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Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

6. Give an example for each type of symbiosis (commensalism, mutualism, parasitism).

7. Differentiate between intraspecific and interspecific competition.

8. Explain in common language how predator and prey cycles work.

Defence Mechanisms

Defence mechanisms are a result of predator-prey interactions evolving over time. Plants for example, use physical defences such as thorns, hooks, spines, etc. and chemical defences against herbivores.

Types of Defence Mechanisms

Passive

- Hiding, camouflage, cryptic colouration (blend in with surroundings)

Active

- Fleeing from predators (takes more energy then passive defences)

Behavioural

- Alarm Calls, Chemical defence mechanisms (poisons, visual warnings to predators, etc.)

Mimicry is a protection in which the one mimicking may gain an advantage by resembling a distasteful species. For example, the Viceroy butterfly mimics the bad tasting Monarch butterfly in order to avoid predation.

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Key Question #17

1. A hawk is a bird of prey and its main food source is mice. Create a predator and prey line graph to show this cycle based on the following information. Use an appropriate scale, label your axis and include a legend. (5 marks)

Year	Hawks	Mice
2009	33	800
2008	46	3500
2007	100	1500
2006	48	550
2005	24	5000
2004	23	4500
2003	109	2800
2002	50	550
2001	36	1500
2000	64	4000

Short Answer: (1 mark each = 2 marks)

a. What is the limiting factor within this ecosystem?
b. Why is there a lag between increases and decreases within the predator and prey populations?

2. Next to habitat destruction, invasive species are an important agent leading to loss of biodiversity due to increased competition with native species. Investigate an invasive species currently threatening Canadian wildlife and create a comprehensive informational pamphlet on the topic. Discuss where the organism came from, how it arrived in Canada, why it is an issue, and what is being down to control it, what citizens can do, etc. Include at least 3 references and some graphics (please use a recognized format, either APA or MLA style referencing). (10 marks) Evaluation Rubic on next page.

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Evaluation of Brochure/Pamphlet

CATEGORY	Level 4	Level 3	Level 2	Level 1
Writing - Grammar	There are no grammatical mistakes in the brochure.	There are no grammatical mistakes in the brochure after feedback from an adult.	There are 1-2 grammatical mistakes in the brochure even after feedback from an adult.	There are several grammatical mistakes in the brochure even after feedback from an adult.
Content - Accuracy	All facts in the brochure are accurate.	99-90% of the facts in the brochure are accurate.	89-80% of the facts in the brochure are accurate.	Fewer than 80% of the facts in the brochure are accurate.
Attractiveness & Organization	The brochure has exceptionally attractive and is well-organized information	The brochure is attractive and is well-organized information	The brochure has well-organized information	The brochure's formatting and organization of material are confusing;
Use of Graphics	Graphics go well with the text; good mix of text and graphics.	Graphics go well with the text, but there are so many that they are distracting.	Graphics go well with the text, but there are too few; brochure is "text-heavy".	Graphics do not go with the accompanying text.
Sources	Careful citation using MLA or APA of 95-100% of the facts and graphics in the brochure.	Careful citation using MLA or APA of 94-85% of the facts and graphics in the brochure.	Careful citation using MLA or APA of 84-75% of the facts and graphics in the brochure.	Sources are not cited accurately on many facts and graphics.

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3. **Case Study -** One species of whale, the blue whale is the largest animal ever known to inhabit the Earth. Unfortunately, these enormous whales, as well as other whale species, have been hunted almost to the point of extinction. A look at the history of agreements between nations to regulate whale hunting illustrates both the problems and successes of international cooperation. The International Whaling Commission (IWC) has instituted various quotas and controls over the years, to limit the harvesting of whales. In 1994, the IWC created a permanent whale sanctuary in Antarctica. Even if the current worldwide ban is lifted, the waters of Antarctica, which are the largest feeding ground for whales in the world, will remain off-limits to commercial whaling vessels. The largest whaling nations are strongly opposed to this agreement. (8 marks)

   Investigate the controversy surrounding the whaling industry.

   a. What is the ecological niche of a whale? Why is it important to limit hunting of whales? (2 mark)
   b. Describe the historical disagreements between countries surrounding the quotas of whales that could be killed. Why do you think these countries have such varying viewpoints? (2 marks)
   c. What measures could international organizations take to enforce international agreements without starting wars? (2 marks)
   d. Nations are very protective of their sovereignty and their right to manage their own affairs. They don’t want to be into a position that permits other countries to tell them what to do. How has the desire to protect sovereignty affected efforts to protect whales? (2 marks)

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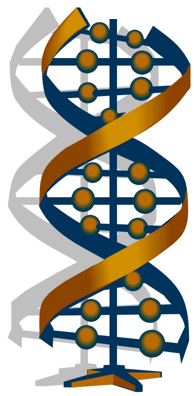

Grade 12, University Preparation Biology

Lesson 18 – Population Ecology

Lesson 18: Population Ecology

Population ecology is the study of a population's vital statistics, and how populations interact with their environment. The interactions within and between populations can influence survival and reproduction of individual members. With this in mind, ecologists go into the field to test theories about species interactions and population dynamics, and to monitor the health of threatened or endangered populations.

In this lesson, you will study ways in which scientists measure population changes by examining dispersion patterns and by determining the size and density of populations.

What You Will Learn

- use appropriate terminology related to population dynamics
- describe the characteristics of a given population, such as its growth, density (e.g., fecundity, mortality), distribution, and minimum viable size
- calculate population density
- estimate total population size both directly and indirectly

Characteristics of Populations

A **population** can be defined as a group of individuals that interbreed. This means a population is a collection of individuals from the same species that occupies the same specified area. Every population has specific **demographics** or characteristics such as size, density, distribution, and number of individuals in various age categories.

Population Density

In order to study populations, scientists must measure or estimate population size and calculate population density. **Population size** is the number of individuals that potentially or actually contribute to the gene pool. The **population density** (D) is the size of a population within a specified space. It is calculated by dividing the total numbers of the species counted (N) by the space (S) the population occupies.

$$\textbf{Population Density (D)} = \frac{\textbf{total numbers of individuals (N)}}{\textbf{Area occupied by the population (S)}}$$

Example:
The population of deer living in a 300 hectare natural preserve is 225.

D = ?
N = 300
S = 225

$$D = \frac{N}{S} = \frac{225 \text{ deer}}{300 \text{ ha}} = .75 \text{ deer/ha}$$

There are 2 different types of population density. **Crude density** measures the number of individuals in the same species within the total area. **Ecological density** measures

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the number of individuals within the area that is actually used by the population. For example, in the above scenario, there were 225 deer living in the 300 ha preserve. The crude density was .75 deer/ha. However, these deer may only be living in the southern 100 ha of the preserve and may never venture into the other 200 ha. The ecological density would then be 2.25 deer/ha (225 deer divided by 100 ha).

Population Dispersion

Different species occupying the same area typically compete for food, space, and other resources. These interactions generally influence the population's density and dispersion throughout a habitat. Populations of organisms can follow 3 different patterns of distribution: **clumped, uniform, or random**.

Clumping is the most common form of dispersion. Species are able to be responsive to conditions and resources which are often patchy within a habitat. With **uniform** dispersion, organisms are more evenly spaced than expected based on chance alone. It generally occurs when competition for resources or space is strong and animals are territorial. **Random** dispersion rarely happens. It only occurs when the conditions of the habitat are almost uniform, and resource availability is steady, and populations neither attract nor avoid one another.

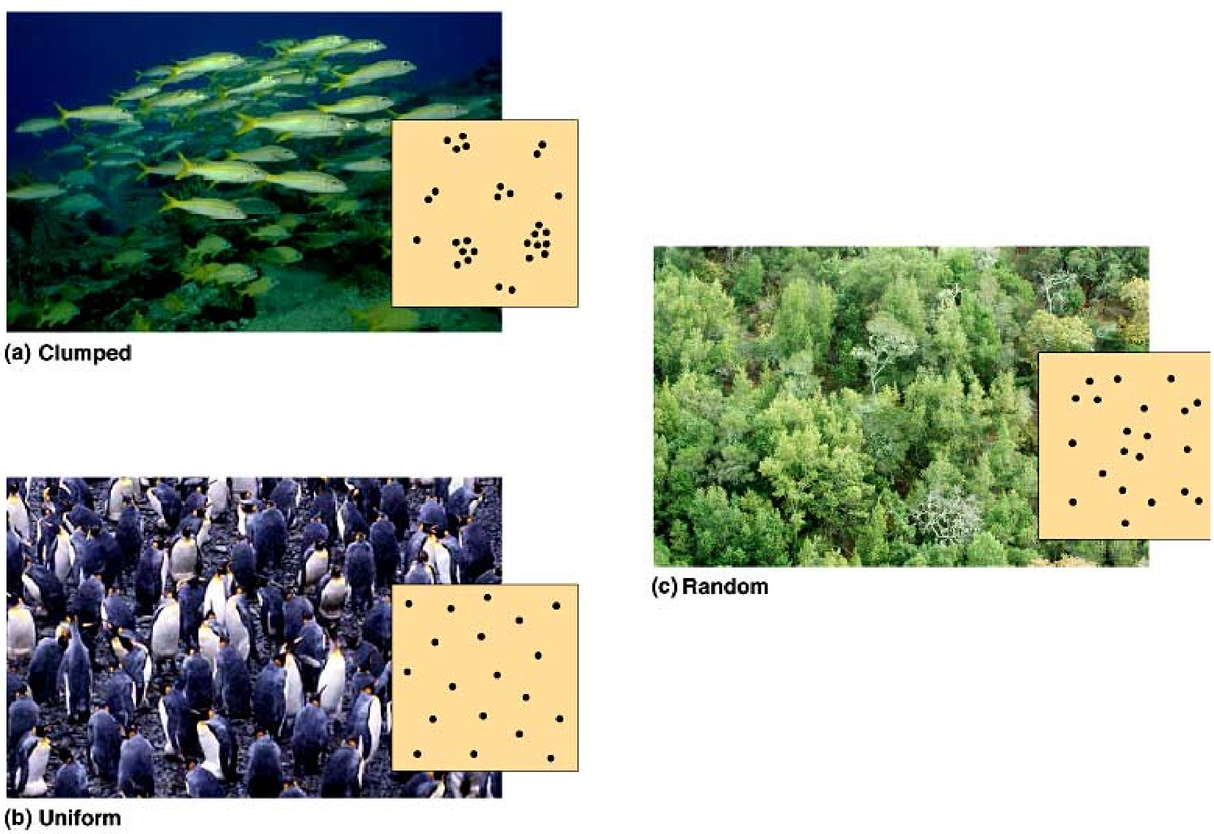

Figure 3: Dispersion Patterns
Source: Pearson Education

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

1. There is a population of 150 bear in a 500 ha park. There is a 100 ha of open water, rivers and lakes in the park. Calculate both the crude and ecological density of the bear.

2. Give 2 more examples of organisms that demonstrate clumped, uniform, and random dispersion.

Calculating Population Size

Biologists use a number of different methods to determine the size of an individual population:

- **Direct**: Count all individuals in the population by hand. This method is time consuming. It also impractical or impossible if the numbers of individuals are high or if the area in which they are located is large.
- **Indirect:** Scientists use indirect observations to estimate the numbers in a population. For example, they may use the number of fecal droppings, the number of tracks left by animals, or the number of nests or burrow that have been found.
- **Estimating the size**: Scientists may use other methods to estimate the size of a population.

If the organism is either immobile, such as trees, and covers a wide area, scientists may estimate their population using a **quadrat sampling** technique. **Quadrats** are sampling areas of the same size and shape such as rectangles, squares and hexagons. The number of individuals is counted within some quadrats being sampled and an average of individuals per quadrat is calculated. This number is then multiplied by the number of quadrats that are within the total area being sampled to give the total number of individuals.

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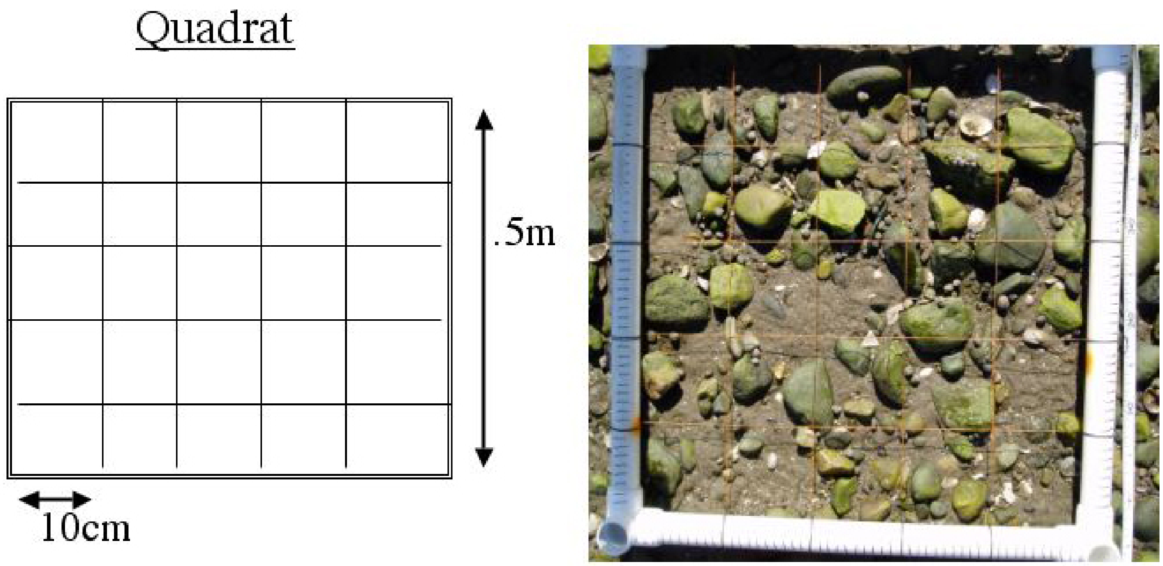

Figure 4: Quadrat Sampling

If the organism is mobile, then a **mark-recapture** technique can be used. This technique involves sampling a number of these organisms and marking them in some way and then releasing them and allowing them to mix with the rest of the population (for example, you may have seen birds tagged around their legs). After a defined period of time, the scientists recapture a second sample of the population. The proportion of marked organisms to unmarked organisms allows the scientists to estimate the size of the population.

In order for the mark-recapture method to be accurate, some assumptions about the population must be made. These assumptions are:

- that the chance of being caught is equal among individuals (i.e. not during breeding season when females are in their burrows)
- that there has been no rapid change in the overall population (there has been no rapid birth, death, immigration or emigration),
- that sufficient time must take place before recapture so that animals have a chance to disperse into the rest of the population
- that animals do not lose their mark during the study period.

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Example:

An endangered bird population is being monitored. Scientists mark 30 birds and release them into the wild. Six months later, researchers recapture 50 of these birds.

They observe that 20 of the birds have their tags on them. In order to estimate the total bird population, they use the following equation:

$$\frac{\text{Total number of marked organisms (M)}}{\text{Total population (N)}} = \frac{\text{Number of marked organism recaptured (m)}}{\text{Size of the second sample (recapture) (n)}}$$

M = 30
N = ?
m = 20
n = 50

$$N = \frac{Mn}{m} = \frac{(30) \times (50)}{20} = 75 \text{ birds}$$

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

3. What method would you use to estimate the size of the following populations?

    a. Canada Geese
    b. Bacteria in a petri dish
    c. Jaguars that are rarely seen
    d. Dandelion weeds in a lawn
    e. Butterflies

4. A study was being conducted to estimate the population of elm in a 10 km by 10 km area. A quadrat system was used. The area was divided into1 km X 1 km quadrats and the elms in 3 quadrats were randomly counted. They scientist found, 5 in one, 3 in another and 2 in the last quadrat. Estimate how many elms would be in the total area.

5. A study was conducted on moose in a local region. 110 moose were captured, tagged and released. 3 weeks later, 50 were recaptured, 10 of which had markers. What is the total estimated population?

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Population Dynamics

Population Dynamics is a branch of life sciences that studies short and long term changes in the size and age structure of populations. It identifies the biological and environmental processes that influence those changes, and studies the way populations are affected by birth and death rates, and by immigration and emigration.

Measuring Population Changes

Demographic variables that determine increases and decreases in population size include:

- Births (Natality) - production of new individuals via birth, hatching, germination, cloning, etc.
- Deaths (Mortality) - described by lifespan and percentage survival at different life stages
- Immigration – introduction into a population via flying, swimming, walking, floating in currents, hitchhiking on/in animals, etc.
- Emigration – dispersal (movement) out of a population
- Type of species (e.g. its **fecundity** or its potential to produce offspring in one lifetime -- a rabbit has a higher fecundity than a human) and the environment in which they live

There are three general patterns for survivorship in species:

Type I: very low mortality; long life expectancy; typically slow to reach maturity and produce a small number of offspring (e.g. humans and elephants) (li

Type II: uniform risk of mortality throughout life

Type III: very high mortality rates (when young); large numbers of offspring; very low average life expectancy (e.g. dandilions, green sea turtle)

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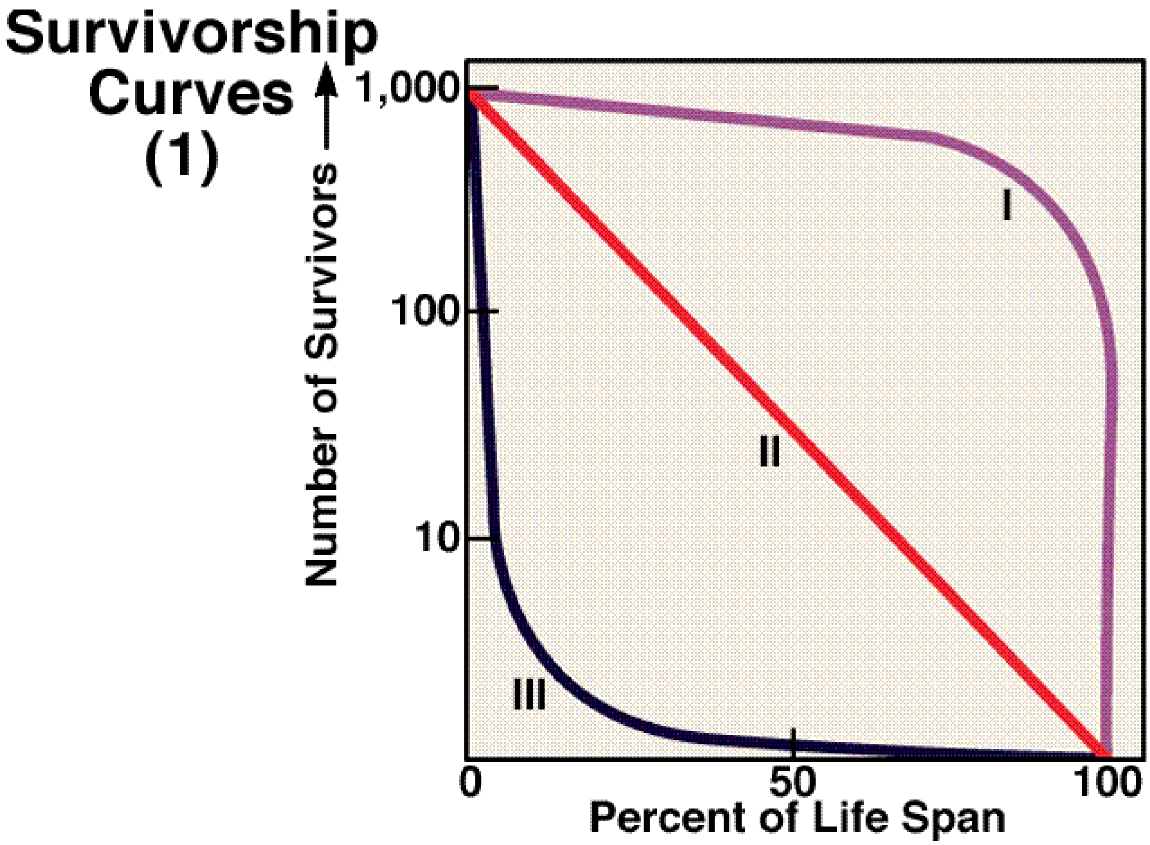

Figure 5: Survivorship Curve
Source: Sylvia S. Mader, Biology

Loss of Species and Biodiversity

Many scientists think we are living during another mass extinction similar to the time of the dinosaur. They fear that by the year 2100, 25 percent or more of all plants and animals that were on the Earth in 1900 will have become extinct. If mass extinction is underway, is a direct result of human actions.

The term **biodiversity** refers to the number and variety of species on Earth. The number of known species is nowhere close to the actual number. Many areas of our planet are still relatively undiscovered, and scientists know there are many species of plants and animals in these locations that have not been identified. Estimates of the total number of species on the planet range from 10 million to 100 million.

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Table 2: Number of Species on the Planet

Category	Species	Totals
Vertebrate Animals		
Mammals	5,416	
Birds	9,956	
Reptiles	8,240	
Amphibians	6,199	
Total Vertebrates		59,811
Invertebrate Animals		
Insects	950,000	
Molluscs	81,000	
Crustaceans	40,000	
Corals	2,175	
Others	130,200	
Total Invertebrates		1,203,375
Plants		
Flowering plants (angiosperms)	258,650	
Conifers (gymnosperms)	980	
Ferns and horsetails	13,025	
Mosses	15,000	
Red and green algae	9,671	
Total Plants		297,326
Others		
Lichens	10,000	
Mushrooms	16,000	
Brown algae	2,849	
Total Others		28,849
TOTAL SPECIES		**1,589,361**

Human population growth is causing dramatic and rapid changes to the environment. Some of these changes are happing so quickly that plants and animals can not adapt, and as a result, are becoming extinct. There are many reasons for extinction; however, the main ones are due to habitat destruction, unregulated hunting, and the introduction of foreign species to an ecosystem.

Sustaining biodiversity preserves ecosystems. It is important to maintain healthy ecosystems because they ensure a healthy biosphere by regulating the flow and cycling nutrients. Each species has a role to play in its ecosystem, and other species depend on that species health for their own survival. Some species are so important, they are

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called **keystone** species. One example of a keystone species is the sea otter. Sea otters live on the Pacific coast of North America and feed on shellfish and sea urchins that live among the coastal kelp beds. In the 1800's, sea otters were trapped for their fur until it was thought that they were extinct. When the sea otters were removed from this ecosystem, a negative sequence of events took place. With the removal of their only predator, the sea urchin population exploded exponentially. Since sea urchins eat kelp, the kelp beds were decimated, which in turn was detrimental to many other aquatic organisms that lived among them. The sea otter has since been reintroduced to the area, and as their populations began to flourish, the kelp beds also returned.

Canada has a **Species At Risk Act** (SARA) which is a small step towards protecting Canadian wildlife. SARA currently applies only to federal lands, such as national parks. This means that because most public, or Crown, lands in Canada are under provincial jurisdiction, only a tiny fraction of Canada is under the direct protection of SARA legislation. SARA does contain some special provisions that can protect areas normally under provincial jurisdiction, but these apply only under special circumstances.

SARA protects only some of the species that are designated "at risk". There are currently 487 species on the species at risk list, but SARA only protects 345 of them. This is because the act excludes a species if protecting them may cause economic or social impacts. These types of exclusions weaken the act's effectiveness, because it is usually economic considerations that have put these species in harm's way in the first place.

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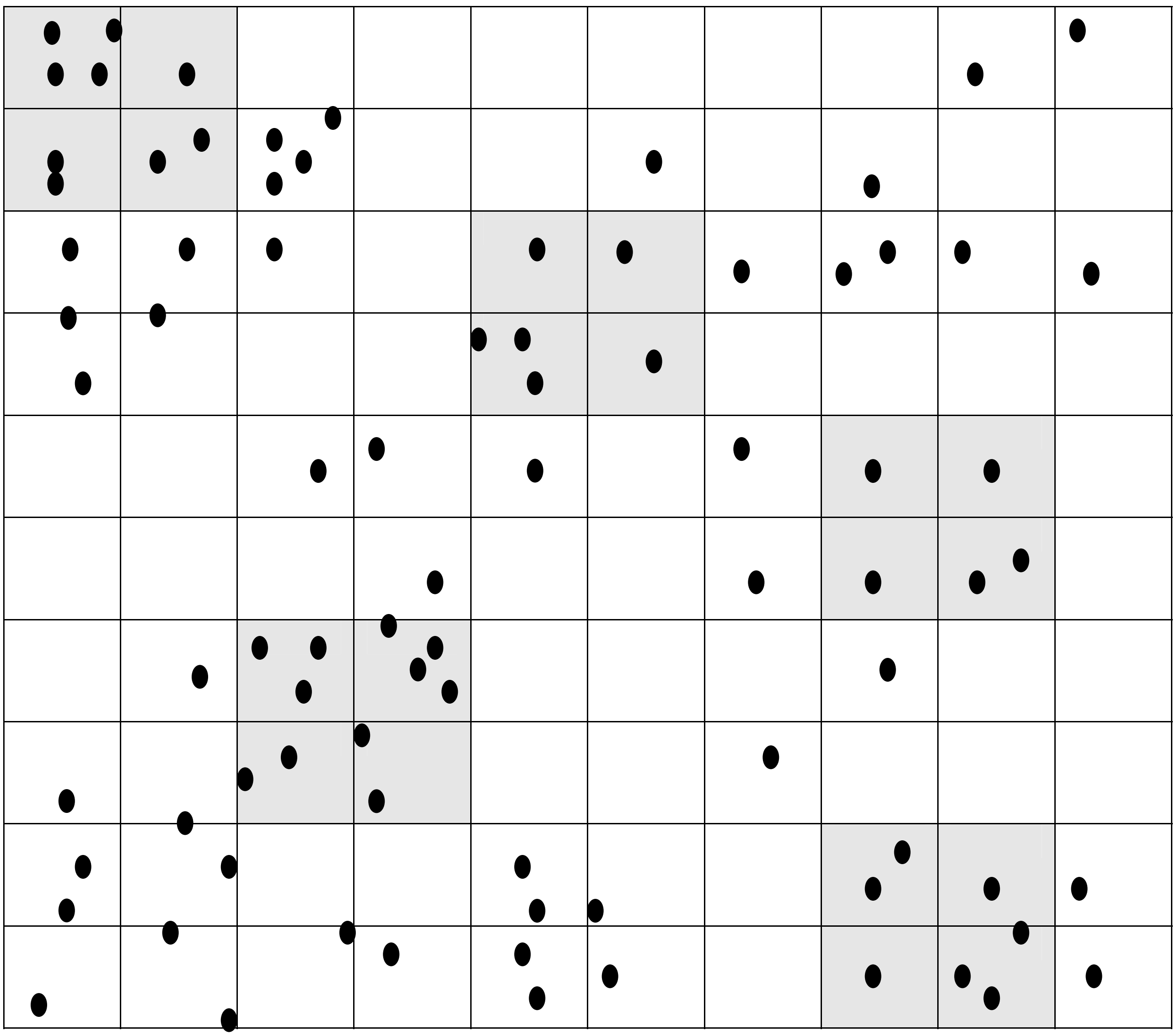
Key Question #18

1. You sampled the following 5 random shaded areas. Using these samples, calculate the estimated total number of poplar trees for the entire area. (8 marks)

   a. How did this estimate compare to the actual number from "direct" counting.
   b. Explain any reasons for these differences.
   c. When would you use this type of sampling technique

Scale: 1 cm = 10 m



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2. A population of lake Ontario salmon is being monitored. A sample of 265 were tagged and released into the lake. Six months later, during spawning season when salmon begin to swim up streams to lay their eggs, 356 salmon were sampled from the lake and 22 had the original tag.

   a. What is the estimated size of the salmon population? (show all your work) (3 marks)

   b. What assumptions about mark-recapture must be taken into consideration for this estimate to be valid. (2 marks)

3. Only a tiny fraction of plants and other organisms that might contain useful drugs have been analyzed and tested, so scientists are concerned that the loss of biodiversity will limit the development of future medicines. Research and describe 5 different organisms that are used in medicine. Describe where they come from and what they do. (10 marks)

4. As mentioned in Lesson 18, the Species At Risk Act does not protect a species if there is a social or economic impact in doing so. Do you think that a species should be protected at any economic cost? Defend your opinion with reasons. (2 marks)

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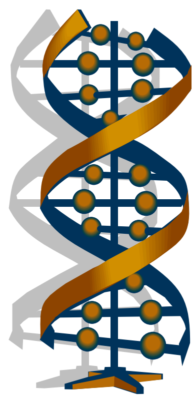

Grade 12, University Preparation Biology

Lesson 19 – Population Growth

Lesson 19: Population Growth

Modelling population growth is an important part of predicting future sizes of species. Through the use of these models, we may be given an indication that a species is being threatened and allowing use to impose certain measures to ensure the species survival. We may also see that a population is exploding, which may require certain steps to bring it back under control before the expanding population threatens other species in its environment. In general, these models help researchers, governments, and wildlife mangers assess the potential size of a species in subsequent years and provide them with information for making future decisions.

In this lesson, you will examine population growth by examining three types of growth models: geometric, exponential and logistic.

What You Will Learn

- use conceptual and mathematical population growth models to calculate the growth of populations of various species in an ecosystem determine, through laboratory inquiry or using computer simulations, the characteristics of population growth of two different populations
- describe the characteristics of a given population, such as its growth, density (e.g., fecundity, mortality), distribution, and minimum viable size

Changes in Population Size

Population growth is measured as the change of a population size over time and is usually expressed as a ratio or percentage.

$$\text{Population Change} = \frac{[\,(\text{births} + \text{immigration}) - (\text{deaths} + \text{emigration})\,]}{\text{Initial population size (n)}} \times 100$$

Population Growth Models

Types of Population Growth

- Geometric Growth
- Exponential Growth
- Logistic Growth

Geometric Growth

In an ideal environment, on with no limiting factors, populations grow at a geometric rate or exponential rate.

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Human populations, in which individuals live and reproduce for many years and in which reproduction is distributed throughout the year, grow exponentially. While populations that have a breeding season grow geometrically. The population grows rapidly during the breeding season and then throughout the remainder of the year it declines.

In geometric growth, the populations grow at a fixed rate in a given time interval. To calculate geometric growth, the population size in one year is compared to the population size at the same time from the previous year. Scientists use the symbol Lambda (λ) to indicate geometric growth rate.

Equation:

$$\lambda = \frac{N(t+1)}{N(t)}$$

N = Population
t = time or year (for example, t could be the population size in year one, so t +1 would be the population size in year 2)

We can rearrange the above equation so that we can determine the population at a given time in the future:

$$N(t) = N(0)\,\lambda^{t}$$

N (t) = the population size at specific time (t)
N(0) = the initial population size
λ = growth rate
t = time

Example:

Each June polar bears give birth. An initial population of 20 bears give birth to 6 cubs, and during the next 12 months, 3 bears die. If the population is growing geometrically, what will the polar bear population be in 2 years? In 8 years?

Answers:

1. Calculate the size of the population over this year (year 1)

   $N(t+1) = 20 + 6 - 3 = 23$

2. Now to figure out the polar bears growth rate, compare this population size with the original population size

   $\lambda = \frac{N(t+1)}{N(t)} = \frac{23}{20} = 1.15$ Therefore, the growth rate is 1.15

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3. Now calculate the population size in two years time

   $N(t) = N(0)\ \lambda^{t}$
   $N(2) = (20) \times (1.15)^{2}$
   $N(2) = 26.45$ Therefore, the population will have 26 polar bears in 2 years

4. Now try calculating the population size in 8 years

   $N(t) = N(0)\ \lambda^{t}$
   $N(8) = (20) \times (1.15)^{8}$
   $N(8) = 61.18$ Therefore, population will have 61 polar bears in 8 years

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

1. What organisms demonstrate geometric growth?

2. A population of Lynx was studied in Northern Ontario. There was an initial population of 120 lynx. During the next 12 months, 10 lynx were born into this population and 40 adults died.

   a. What is the growth rate for this population?

   b. If the growth rate remains constant, what would the population be in 5 years?

Exponential Growth:

When resources are plentiful and unrestricted, population size increases exponentially. Unlike geometric growth that is intermittent, **exponential growth** occurs in populations that grow continuously at a fixed rate in a fixed time-interval. The shape of an exponential growth curve is a **j-shaped.**

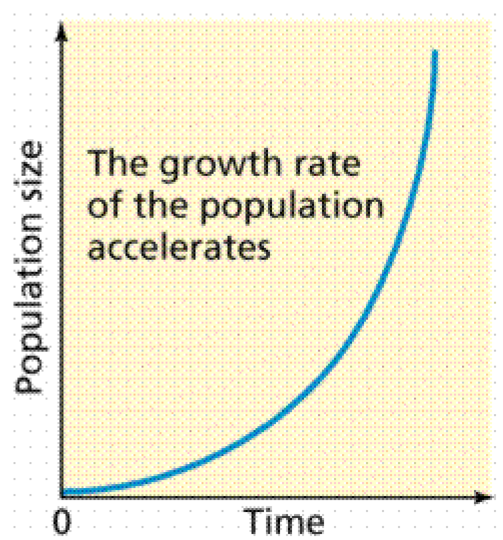

Figure 6: Exponential Growth

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The growth rate is an intrinsic growth rate and is measured per capita. The instantaneous growth rate for exponential growth is calculated by the following equation:

$$\frac{dN}{dt} = rN$$

dN/dt = instantaneous growth rate of the population
r = intrinsic growth rate per capita
N = population size

We can use another formula to approximate a population's doubling time (td) which is occurring in exponential growth.

$$T_d = \frac{0.69}{r}$$

Example:

A petri dish contains a population of bacteria that is growing exponentially. If the intrinsic growth rate (r) is equal to 0.02 per hour and the initial population is 1000, calculate the following:

a. the initial instantaneous growth rate of the population

b. the time it would take for the population to double in size

c. calculate the size of the population after each of 4 doubling times the initial

Answers:

a. r = 0.02 / hour N = 1000

$$\frac{dN}{dt} = rN = (0.02) \text{ X } 1000 = 20 \text{ per hour}$$

Therefore, the instantaneous growth rate is 20 bacteria per hour

b. $T_d = \frac{0.69}{r} = \frac{0.69}{0.02} = 34.5$ hours

c. $T_d =$ 34.5 hours The initial size is 1000

Doubling Time	Time (h)	Population Size
0	0	1000
1	34.5	2000
2	69	4000
3	103.5	8000
4	138	16000

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Support Questions

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3. What organisms demonstrate exponential growth?

4. A zebra mussel population is growing at an exponential rate. If the growth rate is 0.05 per day and the initial population was 100.

   a. Calculate the instantaneous growth rate of the zebra mussel population,

   b. Calculate the time it will take for the population to double in size.

Logistic Growth

Logistic growth is the most common pattern in nature. It is affected by factors that also limit population growth, such as food, light, water and space. The population begins with exponential growth, but then the growth slows down. When there is no net increase in the size of the population (i.e. when the number of births is equal to the number of deaths), then the population has reached the **carrying capacity** of the environment. The shape of a logistic growth curve is a **sigmoid** or **s-shaped** curve.

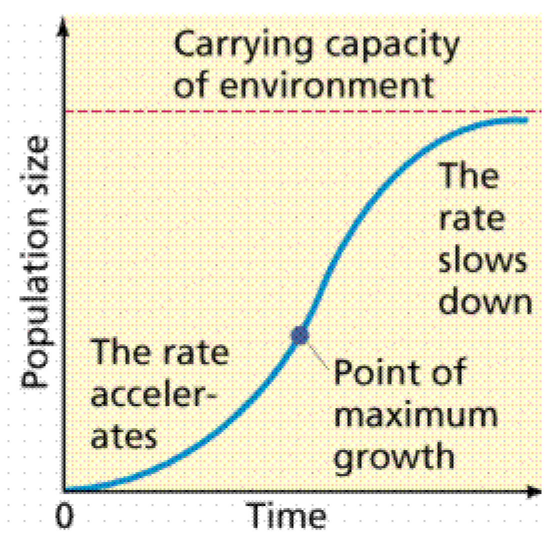

Figure 7: Logistic Growth

$$\frac{dN}{dt} = (r\ max)\ N \left\{\frac{k-N}{k}\right\}$$

dN/dt = instantaneous growth rate

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r max = maximum intrinsic growth rate
N = population size at a given time
k = carrying capacity

What happens if the carrying capacity (k) is close to the population's size (N)? It means that population growth rate approaches zero, therefore no growth occurs.

Example:

A population is growing continuously. The carrying capacity of the environment is 500 individual and its maximum growth rate, r max , is 0.25. Determine the population growth based on a population size of 10, 50, 100, 200, 35, and 500

Answers:

$$\frac{dN}{dt} = (r\ max)\ N \left\{ \frac{k-N}{k} \right\}$$

r max	**Population Size N**	**$\frac{k-N}{k}$**	**Population Growth $\frac{dN}{dt}$**
0.25	10	0.98	2.45
0.25	50	0.90	11.25
0.25	100	0.80	20
0.25	200	0.60	30
0.25	350	0.30	26.25
0.25	500	0.00	0

Support Questions

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5. What organisms demonstrate logistic growth?

6. A population of bacteria is demonstrating logistic growth. The population has a carrying capacity of 1000 individuals and a maximum growth rate of 0.8. Determine the population growth rates based on a population size of 100, 500 and 1000 individuals.

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There are 3 distinct phases in a logistic growth curve. During the lag period, the population is increasing slowly. During the log phase is a period of rapid growth. The stationary phase is when the organism is at or close to the carrying capacity of the environment.

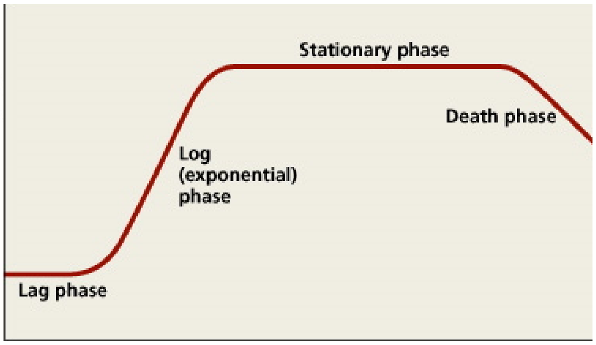

Figure 8: Phases in Logistic Growth Curve
Source: Pearson Education

As the population approaches the stationary phase, the resources available to the organism becomes limited and the population cannot continue to reproduce rapidly, therefore the number of births reduces and the number of deaths increases. A period of equilibrium is achieved. This is considered the carrying capacity of the environment for this organism.

Key Question #19

1. A survey of Yellow Perch was conducted in Lake Winnipeg or several years. The following logistic data was recorded:

Year	Number of Yellow Perch Captured
1994	1000
1995	4000
1996	6000
1997	10 000
1998	13 000
1999	15 000
2000	16 000
2001	12 000
2002	11 000
2003	11 000

a. Create a line graph using the above data. Use an appropriate scale, label your axis and include a legend. (6 marks)

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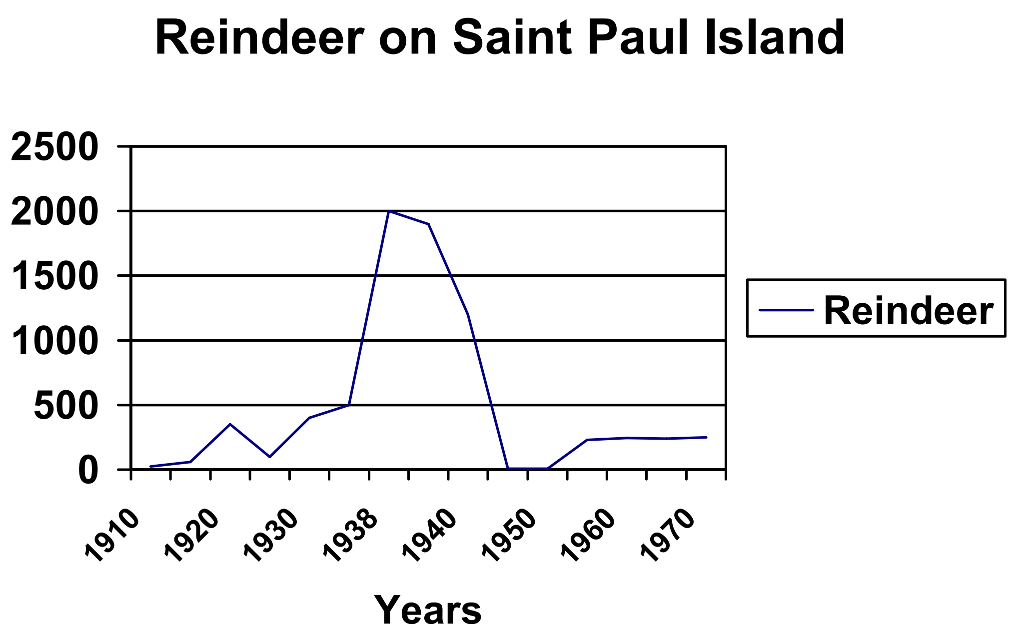
b. What is the estimated carrying capacity? Label the carrying capacity on the graph. (1 mark)
c. What kind of population growth does this graph demonstrating? (1 mark)
d. If the r max is 0.50 for this population, calculate the population growth rates for each of the years. (5 marks)

2. An example of a population growing exponentially that exceeded its carrying capacity occurred on Saint Paul Island of the coast of Alaska in the early part of the century. Reindeer were introduced to replace the native caribou which had been hunted to extinction. The reindeer found the island suitable to their needs and their population exploded. After the crash, the population started to grow again and has reached a stable size of 250 in the heard. (12 marks)



a. What might be some reasons for the giant increase in population in population over such a short period of time? (2 marks)
b. What would have caused the dramatic decrease in reindeer populations? (1 mark)
c. What would have happened had a predator been introduced to this area?(2 marks)
d. What is the new carrying capacity of this system? (1 mark)
e. Research 2 other areas where the introduction of a non-native organism has created problems for the ecosystem. What was the organism, why was it introduced, and what effects have it had? (6 marks)

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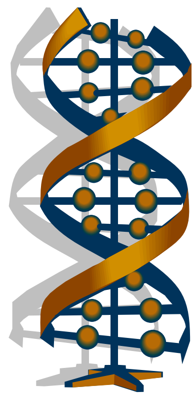

Grade 12, University Preparation Biology

Lesson 20 – Human Population Growth and Ecology

Lesson 20: Human Population Growth and Ecology

Through agriculture, medical, and technological advances, human population has been postponing natural limits on population growth. Using models and equations, scientists have made some predictions about how long our current population growth can continue until we finally do reach our carrying capacity. With this out of control population growth comes numerous environmental problems.

In this lesson, you will examine the nature of human population growth and identify various factors that influence it. Particular emphasis will be placed on the human impact on the environment, including a look at our environmental footprint.

What You Will Learn

- analyse the effects of human population growth, personal consumption, and technological development on our ecological footprint
- assess, on the basis of research, the effectiveness of some Canadian technologies and projects intended to nourish expanding populations
- explain the concept of energy transfer in a human population in terms of the flow of food energy in the production, distribution, and use of food resources

The graph below summarizes historical human population growth over the centuries. One feature to note in this graph is the lack of large fluctuations in human population growth associated with famines or wars. The nature of the exponential growth rate of the human population, in general, has such a powerful upward acceleration that it does not reflect events that have caused reductions in population size. An exception to this is the period of the "black death" or plague in Europe, which produced a noticeable but small downward spike in the curve. The numerous loss of life due to World War I and II produced only small anomalies in the upward trend.

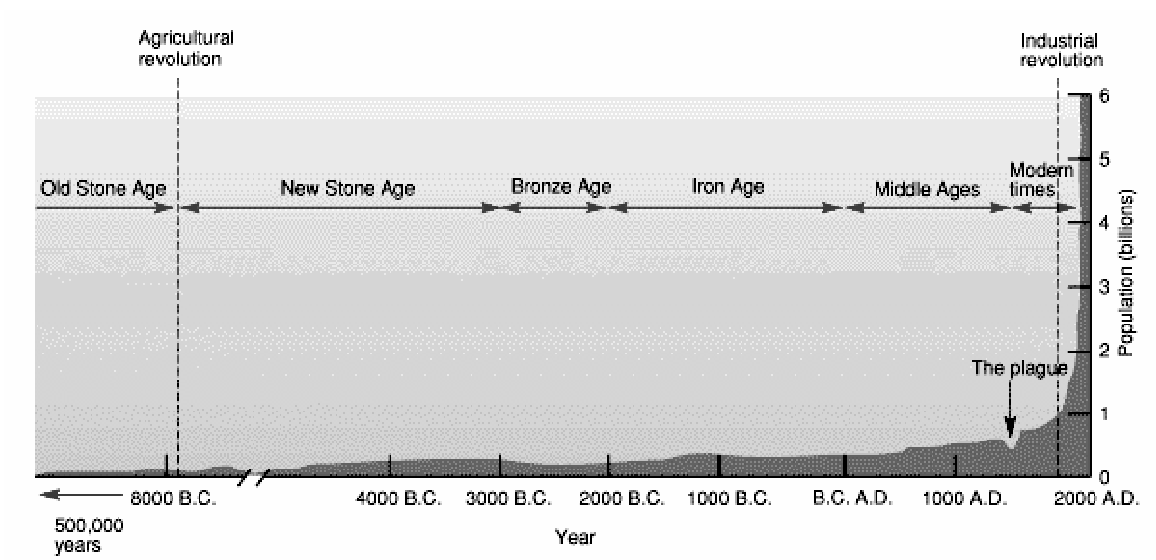

Figure 9: Human Population Growth

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The human population growth of the last century has been truly astounding. From 1950 to 1990, the world's population doubled from 2.5 billion to 5 billion. This doubling time of 40 years is less than the average human lifetime. The world population passed 6 billion just before the end of the 20th century and scientists estimate that the human population may reach 8-12 billion before the end of the 21st century. It is estimated that every hour, more than 10,000 new people enter the world which is a rate of approximately 3 people being born per second!

Factors Affecting Human Population Growth

The factors affecting global human population are very simple. They are fertility, mortality, initial population, and time.

Although the current growth rate of approximately 1.3% per year is smaller than it has been (it peaked at approximately 2.1% per year between 1965 and 1970), it is being applied to a much larger initial population. This means the number of births, a staggering 90 million per year, is at an all time high. Trying to stabilize human population would require a reduction in fertility globally, which is a very difficult process.

Fertility

The current growth of population is driven by **fertility**, or the birth rate of the country. More developed countries have lower fertility rates than the less developed countries. Thus, population growth and the level of development in a country, including literacy rates, are clearly linked.

Fertility is largely controlled by economics and human aspirations for a better life. The high fertility that we see in developing countries is partially due to the need for a large number of people to do agricultural work. In these rural areas, large families have an economic advantage over those who have smaller families. As technology improves, parents realize that having more children decreases rather than increases their standard of living. A dramatic example of this effect occurred in Thailand. When the population realized that their future economic status was linked to the secondary schooling, Thai parents began paying the additional expense to educate their children. In a little as a decade, this change resulted in a decreased fertility rate from about 6 children per couple to only 2.

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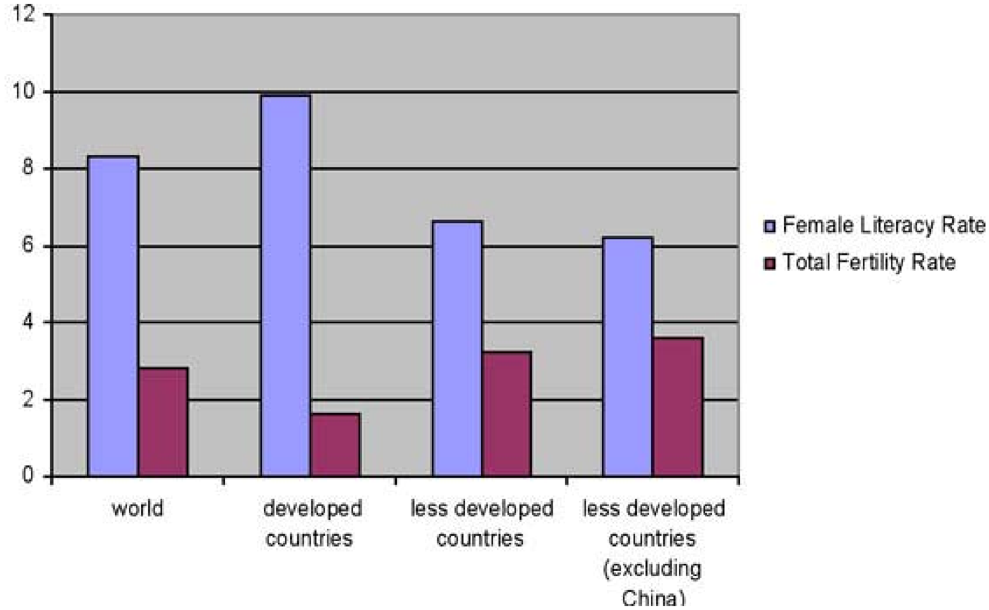

Figure 10: Literacy Rates vs. Fertility

Population-Age Pyramids

While fertility rates are useful, it is also important to look at the demographics of the existing population. **Demography** is the study of characteristics within a population such as age, density, distribution or economic status. Its study can provide key information to predict future growth rates.

One demographic that is studied by scientists is the age distribution within a population. This information can be displayed in **population-age pyramids**. Below is a comparison between a population-age pyramid of a developing country versus developed nations.

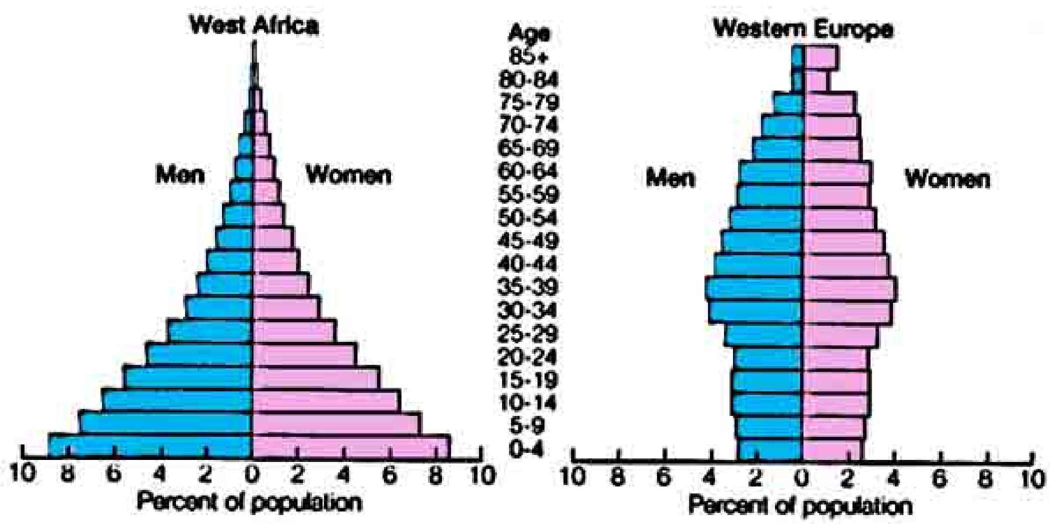

Figure 11: Population Pyramid

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The population/age structure of the developed nations represents a stable population. The pyramid is more rectangular than the triangular shape of the rapidly growing population of the developing country. The developing country has a much larger number of young people which can be indicated by the wider base of the pyramid. The female side of the diagram is particularly important in understanding future growth because fertility is largely controlled by the number of females in their reproductive years (ages 15 - 40).

It can take many decades or even centuries to steepen the slopes of a country's population-age pyramid to become more like those in developed countries. However, such a steepening is essential before populations can become stable. Many countries have tried to implement various methods in an effort to control their population. In China, an aggressive and controversial population control called the "one-child" family policy is bringing remarkable change to age structure and population size.

Mortality

Mortality, or the death rate per individual, is another determining factor of population growth. In the developing world, the death rate has been continuously dropping. There have been many reasons for the decreased mortality rate in developed countries. Some of these include: personal hygiene and improved methods of sanitation, modern medicine, and the development of antibiotics.

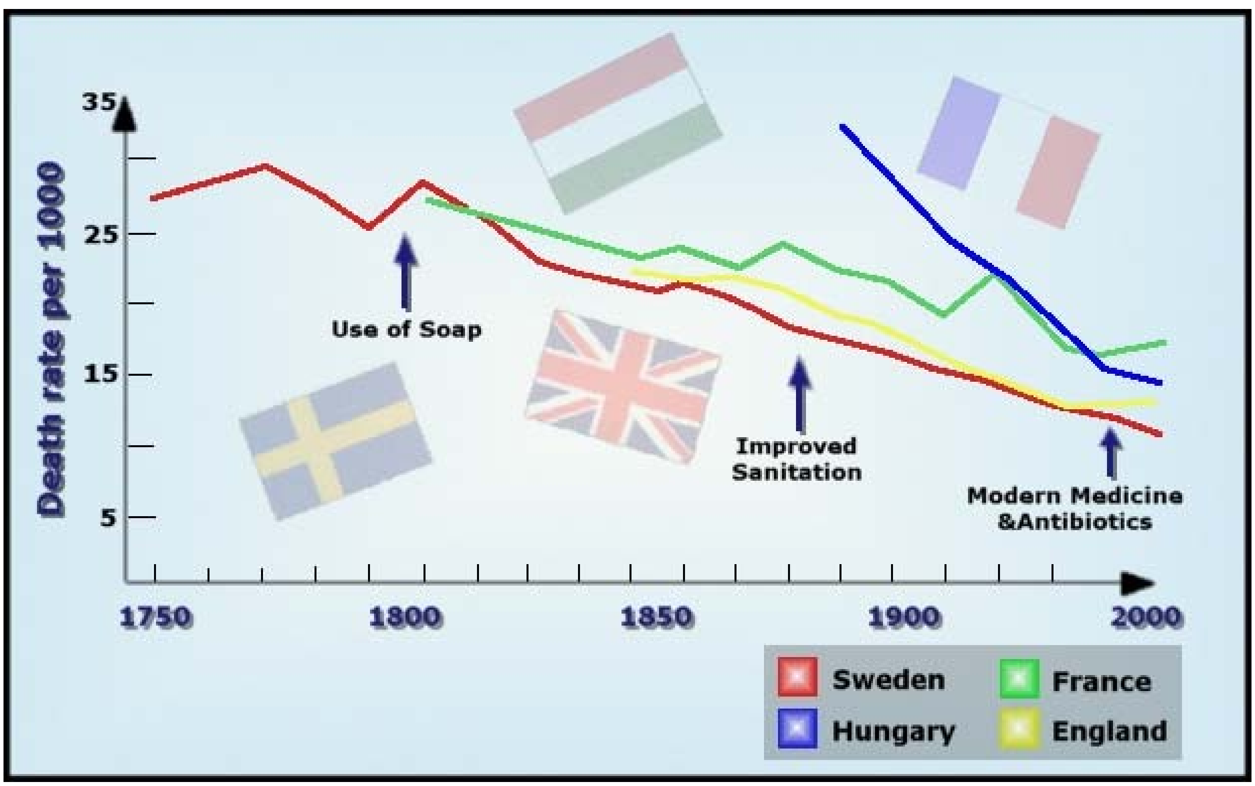

Figure 12: Mortality Rates

The combination of decreasing death rate along with the decrease in birth rate due to changes in the economies, has led to a profound change that we see in the population growth curve in the developed world.

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

1. Why do agricultural based countries have a large population of young people?

2. Population-age pyramids can be used to illustrate countries with rapid, slow and zero growth rates. How would you describe the shape of each of these pyramids?

3. List some reasons why we see a decrease in mortality compared to a few centuries ago.

The Demographic Transition Model

The Demographic Transition Model is the name given to the process that has occurred over the last century and has lead to a more stabilized population growth in developed nations.

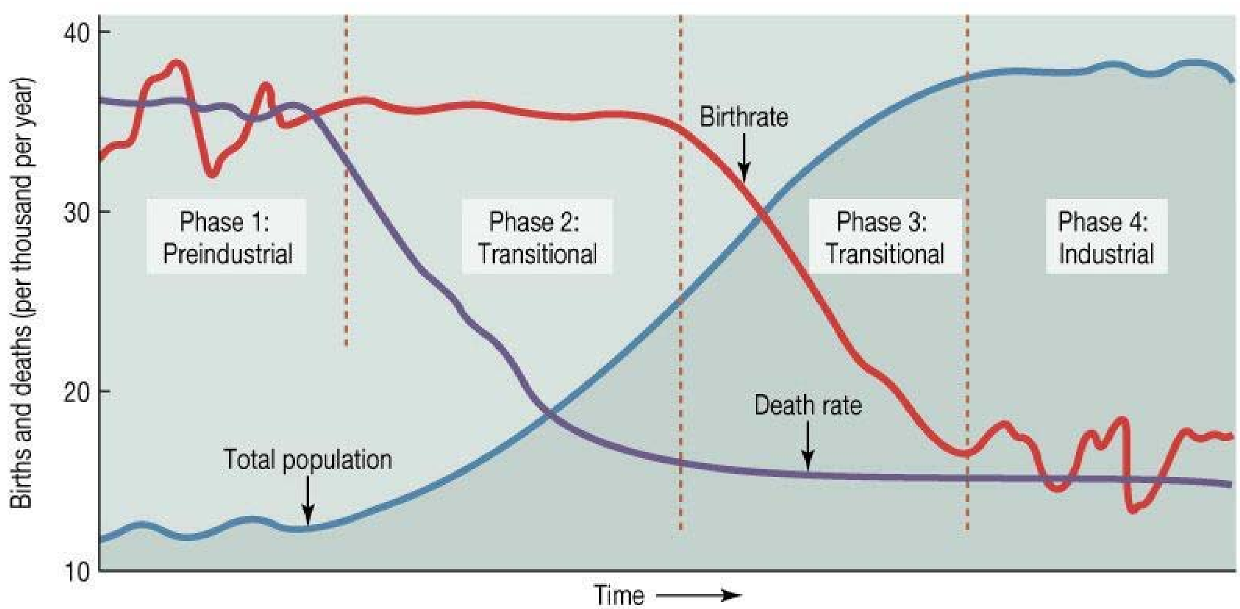

Figure 13: Demographic Transitional Model
Source: World Regions in Global Context

There are 4 phases to this model:

Stage 1: In this early stage birth rates and death rates are both high. Modern medicine had not yet developed to extend life and few used proper hygiene.

Stage 2. In this stage, standards of hygiene and more modern medical techniques improved which began to drive the death rate down, and lead to a significant upward trend in population size. The birth rate remained high, as much of the economy was still based on agriculture.

Stage 3. In this stage, urbanization has occurred. As the cost of supporting an urban family grew, parents were more actively discouraged from having large families. This caused a drop in birth rates, which ultimately came close to the death rate. During this time in the development of Europe, the increasing population led to large scale migration (e.g., to the North America) and extensive global colonialization.

Stage 4. The last stage of the demographic transition is characterized by a higher, but stable, population size. Birth and death rates are both relatively low and the standard of living is much higher than during the earlier periods. Population growth is now approaching zero. The developed world remains in the fourth stage of its demographic transition.

By studying the demographics of various countries, one can determine what stage in this transition model they are in. It is anticipated that a transition like this will occur in all countries as they become further developed, however, this takes time.

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

4. What do scientists believe is the connection between population growth and economic development?

Maintaining our Growing Population

Land and Soil

Much of the world's total land area is not **arable**, which means it is not suitable for agriculture. Only 10% is arable land, and this is not distributed evenly throughout the globe. Some regions of the world are blessed with fertile soils and favourable climates while other regions have poor soil conditions, are prone to drought or flooding or exposed to other harsh conditions that limit the ability to grow food. Approximately one third of the world's land surface supports little or no vegetation. This land consists of

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Antarctica, deserts, mine sites, and urban areas. Nearly all of the world's productive land is already exploited. Most of the land that has not been used is either too steep, too wet, too dry, or too cold for agriculture.

The amount of cropland per capita is declining world-wide. The most severe loss of agricultural land is due to soil degradation. Another reason for the loss of cropland is urbanization. Increasing the yields from available farmland appears to be the key to increased food production. Selective plant breeding has produced high yielding varieties of rice and other crops, particularly corn, sorghum, and wheat. Unfortunately, these high yield varieties reduces genetic diversity and increases the crops vulnerability to pests, which means that it is more dependent on pesticides. There is also the high dependency on fresh water and technology when using these cops, which isn’t always an option in developing countries.

Food

Food is critical for human survival. Improvements in food technology since the 1950’s have led to increased food production. Although food production has now declined over the past 15 years, we still produce enough food on a global scale to adequately feed all of the world’s population. The principal cause of hunger is poverty. Of the 6 billion people, about half live in poverty and at least one fifth are severely undernourished

The minimum amount of food energy that everyone must intake every day is 9900 Joules (J). There are approximately 500 million people who consume less than this per day and two thirds of them live in Asia, Africa, and South America.

We acquire our food from 3 major sources:

- Livestock
- Ocean fisheries
- Grain production

Livestock

Raising livestock has led to forest degradation in Central and South America. This is due to the cutting down and burning of the rainforest in order to create crazing lands for these animals. It has also led to the introduction of foreign species. Raising livestock produces 130 times more waste than humans, which can end up polluting our drinking water, water ways, and cause the loss of fish species due to the growth of toxic algal blooms.

Ocean Fisheries

Fishing catches have reduced due to ocean pollution, global warming, damage to aquatic habitats, and over harvesting.

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Grain Production

It is more energy efficient to consume grain products that it is to consume livestock. To understand this, we must look at food-energy pyramids. An energy pyramid is a graphical model of energy flow in a community. The different levels represent different groups of organisms that might compose a food chain. Starting at the bottom of the energy pyramid, they are as follows:

Producers - bring energy from nonliving sources into the community through photosynthesis

Primary consumers - eat the producers, which makes them herbivores in most communities

Secondary consumers - eat the primary consumers, which makes them carnivores

Tertiary consumers - eat the secondary consumers.

Quaternary consumers - In some food chains, there is a fourth consumer level, that eat the tertiary consumers, and sometimes, but rarely, a fifth.

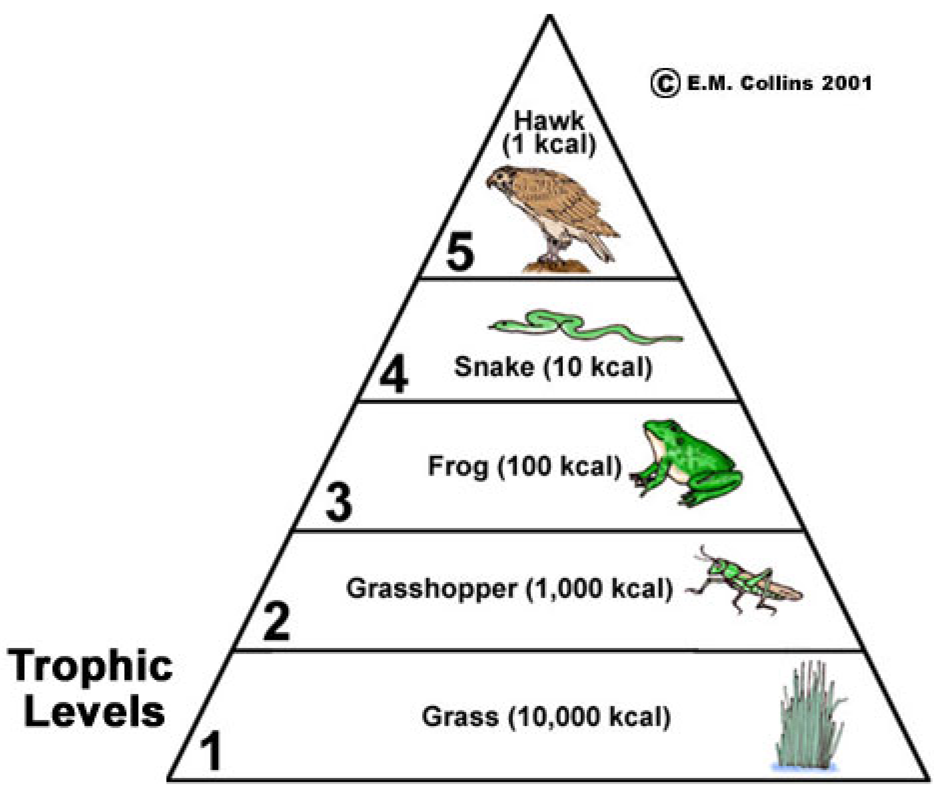

Figure 14: Trophic Levels
Source: E.M. Collins

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Energy flows through this system inefficiently. As one moves up the **trophic** or feeding levels, 90% energy is lost to the environment. Only 10% of the energy that is consumed passes to the organisms in the next level. To be more energy efficient, humans can get more energy by eating producers (grains, vegetables, and fruits) directly rather than from feeding these producers to livestock and subsequently eating the livestock products. Eating organisms early in the food chain or energy pyramid can sustain large populations in countries with insufficient food production. Today, 36% of the world's grain is diverted to feed livestock instead of people. If this amount was reduced by just 10%, 67 million tonnes of grain could be made available to sustain 225 million people!

Water

Over 70% of our Earth's surface is covered by water. Although water is seemingly abundant, there is very little fresh water available. The water cycle on Earth is essentially a closed system. We always have the same amount of water. 97.5% of all water on Earth is salt water, leaving only 2.5% as fresh water. Of this 2.5%, 70 percent of it is frozen in the polar icecaps. Most of the remainder of the fresh water is present as soil moisture, or lies in deep underground aquifers as groundwater that is not accessible for human use. This means that less than 1% is accessible for our use.

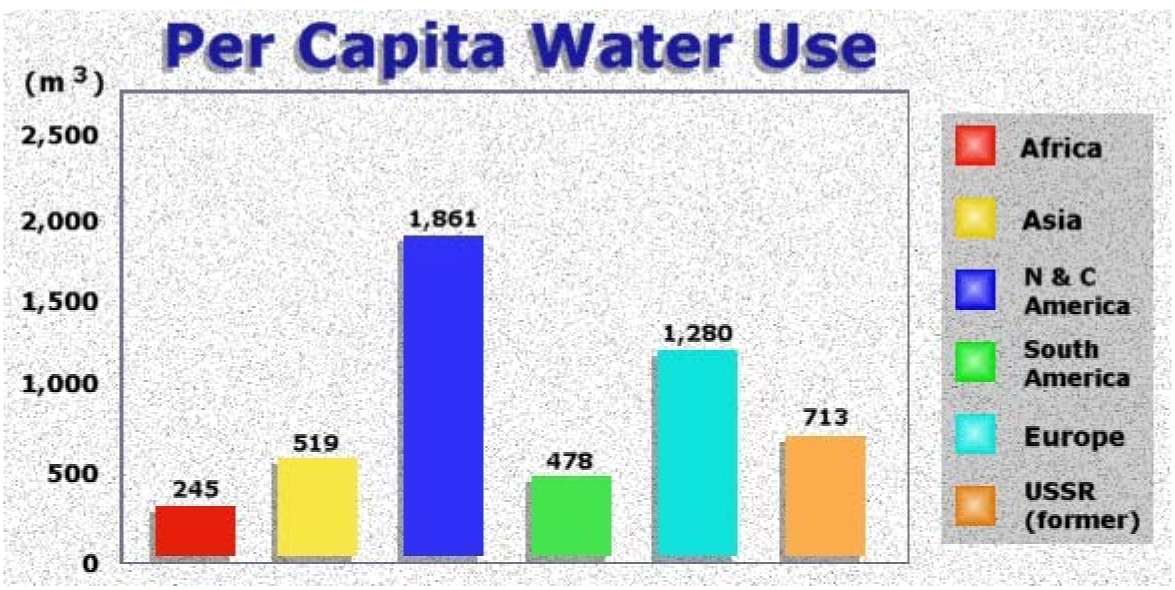

Figure 15: World Water Use
Source: Institute of Geography, USSR

Agriculture is responsible for 87% of the total water used globally. A great deal of water is returned to the earth via surface runoff which is usually contaminated. The World Health Organization estimates that more than 5 million people die each year from diseases caused by unsafe drinking water, and lack of sanitation and water for hygiene.

Many believe that fresh water will be a critical limiting resource for many regions in the near future. About one-third of the world's population lives in countries that are experiencing water shortages. As the population continues to grow rapidly demand for

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fresh water will increase. However, our water supply is decreasing due to pollution and contamination. This means that there will be even more pressure placed on our water resources.

Some solutions may lie in improvements in the efficiency of water use through proper management and modern technologies. Water would be less likely to be wasted if its price was allowed to rise. Incentives for conservation and investments into creating more efficient technologies would also increase.

Air

As more countries become industrialized, more pollutants are added to the Earth's atmosphere. This increase in **air pollution** has resulted in damaged environments and an increase in human health problems.

Acid Rain

Acid rain is generally caused by the industrial emissions of compounds containing sulphur, nitrogen, and carbon when it reacts with the water molecules in the atmosphere to produce acids. This acidic precipitation of dilute sulphuric and nitric acid is deposited in the form of acid rain, snow, gas, and dust. Acid precipitation can erode historical buildings, change soil pH which can effect the growth of forests and crops, and change water pH which can adversely affect fish populations.

Climate Change and the Greenhouse Effect

Another concern linked to air pollution is **global warming** and **climate change**, both of which are linked to the phenomenon known as the **greenhouse effect**.

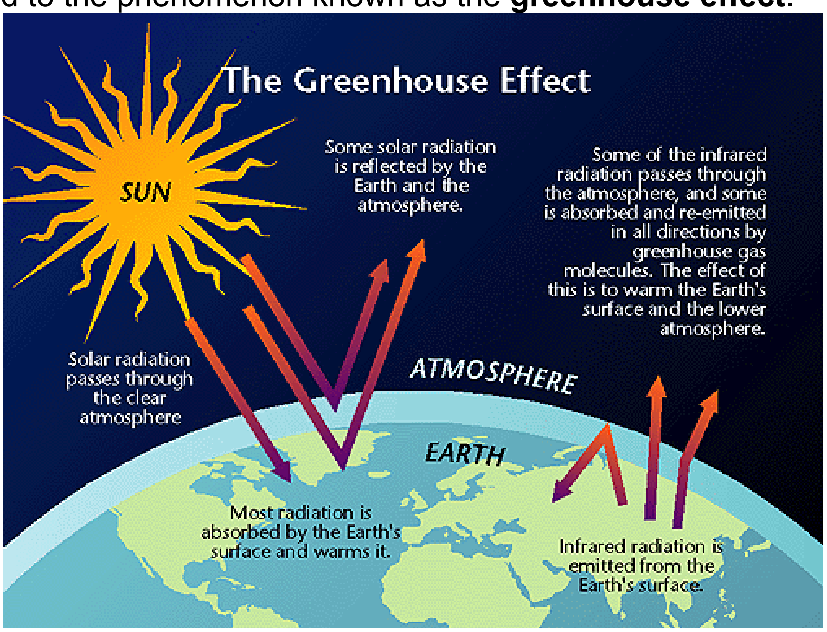

Figure 16: Greenhouse Effect

The greenhouse effect involves specific gases in the Earth's atmosphere (water vapour, carbon dioxide, methane, etc.) that are able to absorb heat. Some of these gases come from human activity. Burning fossil fuels releases tonnes of carbon dioxide in the atmosphere each year; waste sites release methane, and automobile release nitrous oxide and carbon dioxide. These gases allow visible light and some ultraviolet light from the sun to pass through the atmosphere to the Earth's surface. When this light is absorbed, much is reflected back as infrared radiation or heat and absorbed by the greenhouse gases. This creates a thermal blanket in the atmosphere which results in the characteristic range of temperatures. When theses atmospheric gases increase due to human activity, additional global warming is thought to occur.

It is difficult to predict the impacts of changing concentrations of greenhouse gases, but climate specialists agree that the average atmospheric temperatures are rising, and that an increase in greenhouse gases due to human activity, is a contributing cause. Many feel that we will see the following due to climate change and global warming:

- Higher temperatures
- Changing landscapes
- Wildlife at risk
- Rising seas
- Increased drought, fire, and floods
- Stronger storms and increased storm damage
- More heat-related illness and disease
- Economic losses

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

5. Why is not all land arable?

6. If we produce enough food to feed the world's population, why are there still people starving?

7. Why may new wars involve control over water?

8. Explain the role of the greenhouse effect in global warming and climate change.

Ecological Footprint

How much land does it take to support your lifestyle? The ecological footprint measures the amount of nature's resources an individual, a community, or a country consumes in a given year. The Ecological Footprint measures the amount of biologically productive

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land and sea area an individual, all of humanity, an activity, or a region requires to produce the resources it consumes. It also considers the resources required to absorb the waste it generates and carbon dioxide (CO_2) released by burning fossil fuels, and then compares this measurement to how much land and sea area is available.
Humanity's Ecological Footprint

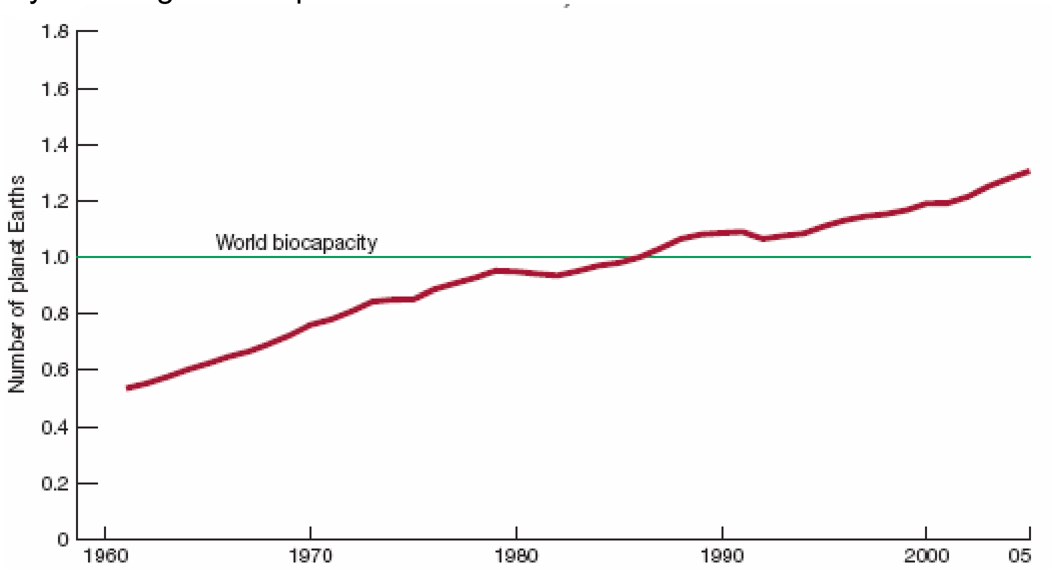

Figure 17: Ecological Footprint
Source: World Wildlife Fund

Biologically productive land and sea includes areas that support human demand for food, fibre, timber, energy and space for infrastructure and absorb the waste products from human activities. **Biologically productive areas** include cropland, forest and fisheries, but do not include deserts, glaciers and the open ocean. The Earth's **biocapacity** is the amount of biologically productive area that is available to meet humanity's needs.

Since the late 1980s, the Ecological Footprint has exceeded the Earth's biocapacity by about 25%. Basically, the Earth's regenerative capacity can no longer keep up with human demand. Humans are turning resources into waste faster than nature can turn waste back into useable resources. As a result, this growing pressure on ecosystems is causing habitat destruction, permanent loss of productivity, threatening both biodiversity, as well as human health.

Current Ecological Footprint Standards use global hectares as a measurement unit which makes data and results globally comparable. A **global hectare** is a common unit that includes the average productivity of all the biologically productive land and sea area in the world in a given year. By using a common unit, different types of land can be compared using a common denominator.

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Living Planet Index

The Living Planet Index (LPI) is an indicator of the health of the planet's ecosystem and global biodiversity. It is based on trends in 1,313 vertebrate populations of species from around the world.

Since 1970 the index has fallen by about 30% which suggests that we are degrading natural ecosystems at a rate unprecedented in human history.

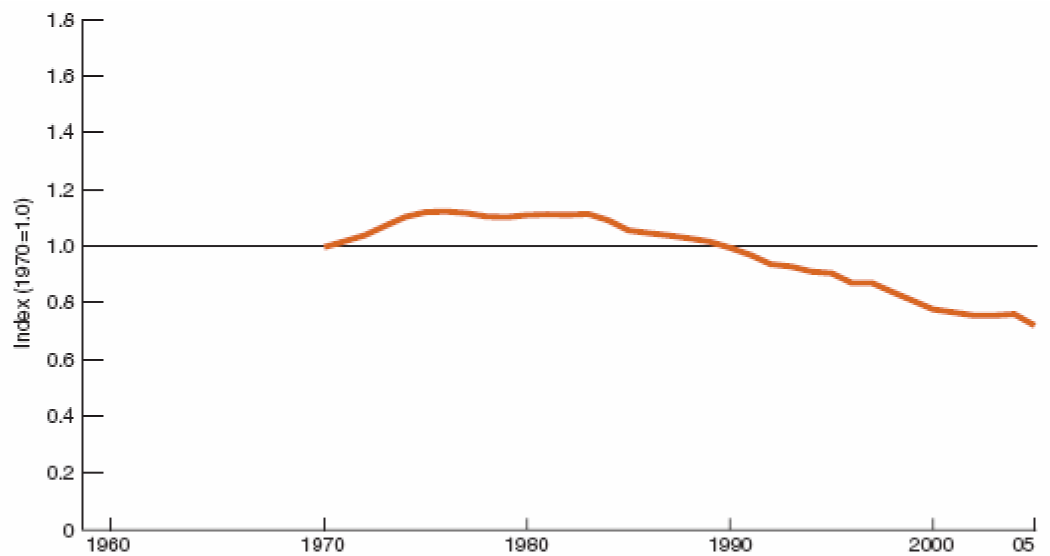

Figure 18: Living Planet Index
Source: World Wildlife Fund

The Living Planet Index provides stakeholders (the general public, scientists and policy-makers) with information on trends vertebrate populations and offers insights into which habitats or ecosystems have species that are declining most rapidly and help guide decision making.

Support Questions

(Reminder: these questions are not to be submitted but reinforce the material taught and are strongly recommended – DO NOT write in this book).

9. Find an online ecological footprint calculator to assist you in calculating your ecological footprint. Try this search: "ecological footprint online".

10. How does the Living Planet Index inform us about the health of ecosystems?

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Canada's Role in Global Initiatives

CIDA – Canadian International Development Agency

CIDA's aim is to reduce poverty, promote human rights, and support sustainable development. CIDA works closely with other federal departments, many kinds of Canadian organizations, international organizations, other donor countries, and of course, developing countries themselves. CIDA provides funding for international development programs and projects through contributions to Canadian and international institutions of many kinds. The Agency also enters into contracts with Canadian companies for the implementation of their programs and projects. Many of their projects focus on education, the environment, health, equity between women and men, humanitarian aid, and private sector development.

Flour Fortification Program

Canada's Wheat Board and International Grains Institute is a member of an international organization looking at the fortification of white flour be fortified with specific amounts of thiamin, riboflavin, niacin, folic acid and iron. With the processing of white flour, it removes a lot of micronutrients, B vitamins, iron and folic acid in particular. By enriching the flour, they're replacing the nutrients that were lost with the very extensive processing that happens to make white flour. This program is aimed at helping to prevent nutrient deficiencies and maintain or improve the nutritional quality of the food supply, such as flour, donated to struggling countries.

Micronutrient Initiative

The Micronutrient Initiative is a Canadian-based organization dedicated to ensuring that the world's most vulnerable, especially women and children, in developing countries get the vitamins and minerals they need to survive. Its mission is t develop, implement and monitor innovative, cost-effective and sustainable solutions for hidden hunger, in partnership with other organizations.

Key Question #20

1. It took thousands of years for the human population to reach 1 billion, but only about 130 years to reach 2 billion. What are the main reasons for this change in growth rate? (2 marks)

2. Investigate how the education of females has contributed to lower birth rates in developing countries. Present your findings, with examples, in a half page report. You may wish to use graphs or charts to help explain your point of view. (5 marks)

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3. On graph paper, create an age-distribution pyramid based on the 2008 census data for Canada (include males/female data, appropriate scale and labels). Answer the following questions related to your population pyramid: (5 marks)

   a. What type of growth is Canada exhibiting?
   b. What might the future hold for your Canada if its population keeps progressing in this way?

Midyear Population, by Age and Sex - Canada: 2008

Age	Both Sexes Population	Male Population	Female Population
Total	33,212,696	16,478,836	16,733,860
0-4	1,707,051	874,621	832,430
5-9	1,739,396	890,175	849,221
10-14	1,978,320	1,015,695	962,625
15-19	2,243,515	1,151,820	1,091,695
20-24	2,231,412	1,146,528	1,084,884
25-29	2,234,883	1,145,454	1,089,429
30-34	2,171,068	1,106,298	1,064,770
35-39	2,226,295	1,126,330	1,099,965
40-44	2,488,119	1,246,877	1,241,242
45-49	2,724,749	1,371,991	1,352,758
50-54	2,514,009	1,254,176	1,259,833
55-59	2,181,959	1,084,990	1,096,969
60-64	1,831,984	912,890	919,094
65-69	1,372,320	667,210	705,110
70-74	1,138,086	531,141	606,945
75-79	997,222	436,185	561,037
80-84	725,379	284,640	440,739
85-89	425,003	149,607	275,396
90-94	199,813	62,382	137,431
95-99	67,791	17,178	50,613
100+	14,322	2,648	11,674

4. a. Some people say that meat-eaters contribute to global warming. Explain this point of view. (2 marks)

   b. Why is vegetarianism considered to be more “energy efficient”? (1 marks)

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5. Research either a Canadian technology or a project intended to help nourish expanding populations. In a paragraph, outline your findings. Include at least 2 references (please use a recognized format, either APA or MLA style referencing). (10 marks)

Evaluation of Report

CATEGORY	Level 4	Level 3	Level 2	Level 1
Organization	Information is very organized with well-constructed paragraphs and subheadings.	Information is organized with well-constructed paragraphs.	Information is organized, but paragraphs are not well-constructed.	The information appears to be disorganized.
Quality of Information	Information clearly relates to the main topic. It includes several supporting details and/or examples.	Information clearly relates to the main topic. It provides 1-2 supporting details and/or examples.	Information clearly relates to the main topic. No details and/or examples are given.	Information has little or nothing to do with the main topic.
Mechanics	No grammatical, spelling or punctuation errors.	Almost no grammatical, spelling or punctuation errors	A few grammatical spelling, or punctuation errors.	Many grammatical, spelling, or punctuation errors.
Sources	All sources (information and graphics) are accurately documented in the desired format.	All sources (information and graphics) are accurately documented, but a few are not in the desired format.	All sources (information and graphics) are accurately documented, but many are not in the desired format.	Some sources are not accurately documented.

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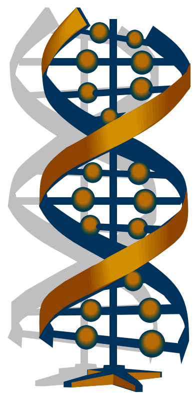

Grade 12, University Preparation Biology

Support Question Answers

Answers to Support Questions

Lesson 17

1. Differentiate between ecological, fundamental and realized niche.

   Ecological niche is the role of the organism within the environment. The Fundamental niche is the organism's role/characteristics and the resources that the organism has the ability to use under ideal conditions. The realized niche is the organism's role/characteristics and the resources it actually does use because competition doesn't allow it to use all that is available.

2. Place the terms: organism, ecosystem, community, population in order from smallest to largest in terms of quantity of individuals.

   Organism, population, community, ecosystem

3. Differentiate between density-dependent and density-independent factors.

   Density-dependent factors have a greater impact on populations as population density either increases of decrease, while density-independent factors will influence population size regardless of the population's density.

4. Identify the following as either density-dependent or density-independent:

   a. intraspecfic competition: density-dependent
   b. human interference: density-independent
   c. a hurricane: density-independent
   d. disease: density-dependent

5. What would be some limiting factors for a tree growing in the rainforest?

   Light, nutrients and water would be some limiting factors

6. Give an example for each type of symbiosis (commensalism, mutualism, parasitism).

   - Commensalism: flatworms live attached to the gills of the horseshoe crab, obtaining bits of food from the crab's meals, but crab is unaffected
   - Mutualism: bee/flower interaction; bee gets pollen and flower gets pollinated
   - Parasitism: tapeworm in an animal's intestine

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7. Differentiate between intraspecific and interspecific competition.

   Intraspecific competition occurs between members of the same population, while interspecific competition occurs between different species.

8. Explain in common language how predator and prey cycles work.

   The size of the predator and prey populations affect each other. For example, as the size of the prey population increase, there is more food for the predator, so its population increases. As the predator increases, it eats more prey which cause the population of the prey to decrease. This eventually causes a decrease in the size of the predator population and the cycle begins all over again.

Lesson 18

1. There is a population of 150 bear in a 500 ha park. There is a 100 ha of open water, rivers and lakes in the park. Calculate both the crude and ecological density of the bear.

   Crude density
   D = N/S = 150 bears / 500 ha = 0.3 bear / ha

   Ecological density
   D = N/S = 150 bears / (500-200) ha = 150 bears / 300 ha = .5 bear / ha

2. Give 2 more examples of organisms that demonstrate clumped, uniform, and random dispersion.

   Clumped: cattails at river's edge, buffalo herd
   Uniform: eagles (nest 2 km apart from next pair), tree reforestation areas
   Random: some spiders, anything egg or larvae that floats freely in the water

3. What method would you use to estimate the size of the following populations?

   a. Canada Geese: mark-recapture
   b. Bacteria in a petri dish: quadrat
   c. Jaguars that are rarely seen: indirect observations (tracks, feces, etc.)
   d. Dandelion weeds in a lawn: quatdrat
   e. Butterflies: mark-recapture

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4. A study was being conducted to estimate the population of elm in a 10 km by 10 km area. A quadrat system was used. The area was divided into1 km X 1 km quadrats and the elms in 3 quadrats were randomly counted. They scientist found, 5 in one, 3 in another and 2 in the last quadrat. Estimate how many elms would be in the total area.

Average Elm in each quadrat: = (5 + 3 + 1) / 3 = 3 Elm per quadrat
Quadrat Sample area is 1 km X 1 km = 1 km^2
Total Study Area is 10 km X 10 km = 100 km^2
100 km^2 / 1 km^2= 100

Therefore, total number of Elms is: (3 Elm X 100) = 300 Elms in the 100 km^2 area.

5. 13. A study was conducted on moose in a local region. 110 moose were captured, tagged and released. 3 weeks later, 50 were recaptured, 10 of which had markers. What is the total estimated population?

M = 110
n = 50
m = 10

$$N = \frac{Mn}{m} = \frac{110 \times 50}{10} = 550 \text{ moose}$$

Lesson 19

1. What organisms demonstrate geometric growth?

Any organism with a breeding season

2. A population of Lynx was studied in Northern Ontario. There was an initial population of 120 lynx. During the next 12 months, 10 lynx were born into this population and 40 adults died.

a. What is the growth rate for this population?
b. If the growth rate remains constant, what would the population be in 5 years?

a. What is the growth rate for this population?

$$\lambda = \frac{N(t+1)}{N(t)} = \frac{90}{120} = 0.75$$ Therefore, the growth rate is 0.75

b. If the growth rate remains constant, what would the population be in 5 years?

$N(t) = N(0)\ \lambda^{t}$
$N(2) = (120) \times (0.75)^{5}$
$N(2) = 28$ Therefore, the population will have 28 Lynx 5 years

3. What organisms demonstrate exponential growth?

Any organism that increases its growth rapidly and doubles its population very quickly (e.g. bacteria, mice, etc.).

4. A zebra mussel population is growing at an exponential rate. If the growth rate is 0.05 per day and the initial population was 100.

a. Calculate the instantaneous growth rate of the zebra mussel population,
b. Calculate the time it will take for the population to double in size.

a. r = 0.05 / day N = 100

$$\frac{dN}{dt} = rN = (0.05) \times 100 = 5 \text{ per day}$$

Therefore, the instantaneous growth rate is 5 mussels per day

b. $$T_d = \frac{0.69}{r} = \frac{0.69}{0.05} = .045 \text{ days}$$

5. What organisms demonstrate logistic growth?

Any organism that begins with exponential growth then the growth slows as it reaches a carrying capacity within its environment.

6. A population of bacteria is demonstrating logistic growth. The population has a carrying capacity of 1000 individuals and a maximum growth rate of 0.8. Determine the population growth rates based on a population size of 100, 500 and 1000 individuals.

$$\frac{dN}{dt} = (r\ max)\ N \quad \frac{k-N}{k}$$

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r max	Population Size N	k-N / k	Population Growth dN / dt
0.8	100	(1000-100)/1000 =0.9	72
0.8	500	0.5	200
0.8	1000	0	0

Lesson 20

1. Why do agricultural based countries have a large population of young people?

   There is a need for more children to help work the land.

2. Population-age pyramids can be used to illustrate countries with rapid, slow and zero growth rates. How would you describe the shape of each of these pyramids?

   Rapid Growth – triangular shape; broad base, sharp sloped sides upwards
   Slow Growth – more square or rectangular shape; more narrow base, may bulge in middle
   Negative Growth – rectangular shape; almost uniform distribution

3. List some reasons why we see a decrease in mortality compared to a few centuries ago.

   Increased hygiene, medicine and technology

4. What do scientists believe is the connection between population growth and economic development?

   As nations become more industrialized, they require fewer t

5. Why is not all land arable?

   Much of the land on earth is rocky, desert, covered in forest, urbanized, frozen etc. and therefore is not productive for crops, so is not arable.

6. If we produce enough food to feed the world's population, why are there still people starving?

   Half of the world live in poverty and cannot afford to buy food, even if they had access to it. Although we produce enough to feed the world, developed

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countries consume more than they require, and hold much of the world's food reserves.

7. Why may new wars involve control over water?

   Less than 1% is available for our use. Many countries are experiencing water shortages, and as population grows, there will be more of a demand for it. This could mean wars could be fought over fresh water access.

8. Explain the role of the greenhouse effect in global warming and climate change.

   The greenhouse effect is a process where radiant heat being reflected back from the Earth's surface is trapped in atmospheric gases. Climate specialists state that the average atmospheric temperatures are rising, and that an increase in greenhouse gases due to human activity, is a contributing cause. This increase in atmospheric temperatures is thought to contribute to global warming and climate change.

9. Find an online ecological footprint calculator to assist you in calculating your ecological footprint. Try this search: "ecological footprint online".

   Some suggestions: http://www.myfootprint.org/ , http://footprint.wwf.org.uk/

10. How does the Living Planet Index inform us about the health of ecosystems?

    It monitors vertebrate populations and notes any changes or decreases. This can provide us with insight to how the overall ecosystem is doing.

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