Lesson Description

In this lesson we:

- Look at population size with respect to:
  - The definition of population
  - What characterises a population?
  - What are the parameters of a population?
  - How do we measure the size of a population?
    - Counting
    - Sampling
  - Defining limiting factors and carrying capacity
  - Types of population growth
    - Logistic growth
    - Geometric growth

Challenge Question

GRAPH A below represents the number of bacteria in a growth culture over a period of time.

a.) During which period (A, B or C) did natality exceed mortality for many hours?

b.) Account for the pattern of growth during Period B.
Definition of Population

A population is the total number of individuals of the same species that occupy a specific area and that are able to interbreed (are able to breed with one another) at a specific time.

Characteristics of a Population

- Density: The number of individuals per unit area or per unit volume.
- Sex ratios: The ratio of male and female individuals within the population.
- Pattern of distribution: The way in which individuals of a population are distributed over the area that they occupy. The distribution may be random, clumped or uniform.

Parameters of a Population

- Population parameters are factors that characterise a population. A population parameter is a factor that determines the size of a population and the changes that occur to the size of the population over time. Parameters that affect population size are:
  - natality – the rate at which new individuals are added to a population through reproduction
  - mortality – the rate at which new individuals are lost to a population through death
  - immigration – the rate at which new individuals join a population from somewhere else
  - emigration – the rate at which individuals from a population leave it to go somewhere else.
Measuring Population Size

- **Counting** is the easiest method for measuring the size of a population. All the organisms in the population are counted.
- To use the direct count method all the organisms must be visible, be reasonably large and they must stand still.

- **Sampling** is an alternate method to counting. There are several different methods and they are used on populations where the organisms are small and move around a lot.
- **Quadrats** - A square frame that has a known area. For example, a metal quadrat that is 0.5 m by 0.5 m will have an area of 0.25 m².
  - This method can be used to determine the types of species, the number of individuals of each species and the distribution of each species in a particular **habitat**.
  - Stand with your back to the area that you want to sample and throw the quadrat over your shoulder into the area. This will give you a **random sample**. In random samples, you do not choose where the quadrat will land, so the results are likely to be more representative of the area.

- **Transects**: A line formed by a tape or rope that is stretched across a representative part of an **ecosystem** being investigated. As you walk along the tape or rope, you identify each plant or animal that is found on the line and then you record its position.
  - A transect is useful for finding out how the species of plants and animals change across an ecosystem,
A single transect will provide a single sample and may not provide much information about all the different species in a community. It can only provide information about the plants or stationary animals in an ecosystem.

Traps: Traps capture small animals in a habitat. Pitfall traps consist of a jar or cup with a smooth inner surface that is buried in the ground so that the upper rim is level with the ground’s surface. Small animals such as beetles and spiders fall into the trap and cannot get out.

Sticky traps consist of strips of paper with a sticky surface. They are hung on the branches of trees or shrubs. Small flying insects stick to the surface of these traps.

Small mammal traps such as mouse traps are used to capture mammals such as mice and shrews.

Direct observation: Large animals or plants can be seen by direct observation. As you walk around an ecosystem, you record the different species of amphibians, reptiles, birds, mammals, trees and bushes that you can see. Binoculars are useful for observing birds or mammals that are far away.

Field guides: These books are used for identifying all the plants and animals that you find. There are many different kinds of field guides that specialise in a particular group of organisms, e.g. reptiles, birds or mammals. Field guides for plants tend to be specific for a particular region, e.g. for the trees of the Kruger National Park.

Mark-and-recapture method: This method is used to measure the size of a population of animals. In this method: A number of animals from a population is captured and they are marked in some way and then released some time later another group of animals from the same population is captured the number of marked animals is counted (recaptures from the first sampling).

The formula to determine the population size is:

\[
\text{Population size} = \frac{\text{number in the first sample} \times \text{number in the second sample}}{\text{number of marked individuals in the second sample}}
\]

When carrying out the mark-and-recapture method in the field, it is important to make sure that the results are as accurate as possible by choosing a population that is stable.
Limiting Factors and Carrying Capacity

- **Limiting factors** that affect population growth, such as competition, predation and diseases, are all **density-dependent factors**. Other limiting factors, such as earthquakes, floods and fires, are all **density-independent factors**. This means that the effect of these factors is not related to the size of the population. They affect the same percentage of a population whether it is small or large.

- **Carrying capacity** of an ecosystem determines the maximum number of individuals of a population that the ecosystem can support. It is linked to the availability of resources.

Population Growth

- The size of a population may change over time.
- There are only four processes that
  - Birth, immigration, death and emigration
- **Logistic growth** has several phases.
  - Lag phase – slow growth
  - Exponential growth phase – population grows rapidly
  - Stable phase – population stops growing

![Lag phase - exponential growth phase - stable phase](image1)

![fluctuations around first stable phase](image2)

*(Life Sciences for All, Macmillan 2012, p281)*

- **Geometric growth**: a population doubles in a set amount of time. Geometric growth does not go on forever.
- Limiting factors such as lack of food, water or space will affect the rate at which a population is growing.

![Number of individuals vs time](image3)

![Number of individuals vs time](image4)

*(Life Sciences for All, Macmillan 2012, p283)*
Test Yourself

Refer to the graph below for Question 1 and 2

**Relationship between populations of jackals and rabbits over time**

<table>
<thead>
<tr>
<th>Year</th>
<th>Population size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1936</td>
<td>100</td>
</tr>
<tr>
<td>1946</td>
<td>200</td>
</tr>
<tr>
<td>1956</td>
<td>500</td>
</tr>
<tr>
<td>1966</td>
<td>100</td>
</tr>
<tr>
<td>1976</td>
<td>200</td>
</tr>
<tr>
<td>1986</td>
<td>300</td>
</tr>
<tr>
<td>1996</td>
<td>400</td>
</tr>
</tbody>
</table>

**Question 1**
What effect does a decrease in the number of rabbits have on the jackal population?

A. Jackal population decreases
B. Jackal population is eliminated from the habitat after a long period of time
C. Jackal population increases
D. Both the rabbit population and the jackal population are eliminated from the habitat

**Question 2**
What effect does a decrease in the number of jackals have on the rabbit population?

A. Rabbit population decreases
B. Rabbit population is eliminated from the habitat after a long period of time
C. Rabbit population increases
D. Both the rabbit population and the jackal population are eliminated from the habitat
Refer to the diagram below for Questions 3 - 5

**Question 3**
Identify the growth form indicated by the graph
A  Linear  
B  S-shaped  
C  J-shaped  
D  Geometric

**Question 4**
Identify the phases labelled A
A  Lag phase  
B  Exponential phase  
C  Stabilising phase  
D  Logarithmic phase

**Question 5**
Identify the phases labelled A
A  Lag phase  
B  Exponential phase  
C  Stabilising phase  
D  Logarithmic phase
Improve your Skills

Question 1

Look at the Figure showing yeast budding. This is the way that yeast cells reproduce.

![Yeast budding](Image)

(Life Sciences for All, Macmillan 2012, p282)

In an experiment, yeast cells were grown in a glucose solution in a test tube and kept at a temperature of 30 °C. Every two hours, a drop was taken from the mixture and examined under a microscope. The number of cells per unit area was counted. The results of the experiment are shown in the Table.

<table>
<thead>
<tr>
<th>Time</th>
<th>Number of yeast cells (per unit area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>175</td>
</tr>
<tr>
<td>8</td>
<td>350</td>
</tr>
<tr>
<td>10</td>
<td>515</td>
</tr>
<tr>
<td>12</td>
<td>595</td>
</tr>
<tr>
<td>14</td>
<td>640</td>
</tr>
<tr>
<td>16</td>
<td>655</td>
</tr>
<tr>
<td>18</td>
<td>660</td>
</tr>
</tbody>
</table>

a.) Draw a line graph to illustrate these results. (10)
b.) On your graph, indicate the lag phase, the exponential growth phase (or log phase) and the stable phase. (3)
c.) Describe the shape of the graph. (1)
d.) During which time period did the greatest increase in the number of yeast cells occur? (1)
e.) After six hours, there are 175 yeast cells per unit area. How long does it take to double this number? (2)
f.) Why do you think the growth rate of the population slowed down? (1)
Question 2

A population of mice in a field of mealies was studied for one week. The population parameters (per thousand mice) were calculated for that week. Six months later the investigation was repeated. The results are recorded in a table.

<table>
<thead>
<tr>
<th>Population parameter</th>
<th>Week 1</th>
<th>Week 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth rate</td>
<td>110</td>
<td>270</td>
</tr>
<tr>
<td>Immigration</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Death rate</td>
<td>145</td>
<td>200</td>
</tr>
<tr>
<td>Emigration</td>
<td>10</td>
<td>70</td>
</tr>
</tbody>
</table>

The rate of change of a population can be calculated by the following formula:

\[ \text{Rate of change} = (\text{birth rate} + \text{immigration rate}) - (\text{death rate} + \text{emigration rate}) \]

a.) Calculate the rate of change for Week 1. (4)
b.) What was happening to the size of the population in Week 1? (1)
c.) Calculate the rate of change for Week 2. (4)
d.) What was happening to the size of the population in Week 2? (1)
e.) How had the rate of change in the population changed in the six months between the two investigations? (1)
f.) One of the weeks was in February, the other in July. In which month do you think each week was? Give reasons for your answer using ALL the information you have been given. (6)