

Week 4

UNIT 3: POPULATION

Learning Outcome

At the end of this unit, students should be able to:

- Describe the characteristics of a population using examples.
 - Characteristics are:
 - size: number, natality, mortality
 - space: territory, home range, distribution, density.
- Explain survivorship curves in relation to natality and mortality.
- Explain the advantage genetic variation has for the survival of a population.
- Explain the effect genetic isolation can have on a population.

Introduction

- A **population** is a group of organisms of the same species that lives in a particular area at one particular time.
- When defining population, you need to know the type of individual, the time and the place.

For example

- All the black robins on Nomuka Island in September 2011.
- All the mateloi on Tonga High School's rugby field in August 2011.

FEATURES OF A POPULATION

1. Population Number (Size)

(i) **Natality (Birth rate):** the number of live births per 1000 people per year.

In humans this is calculated as percentage rate at the mid-point of the year.

$$\text{Percentage rate} = \frac{\text{number of births per year}}{\text{Total population}} \times 1000$$

(ii) **Mortality (Death rate):** the number of deaths per 1000 people per year.

(iii) **Population size:** the total number of organisms in a population.

- It is difficult to count all the members of a population, so a sample of the population is taken.

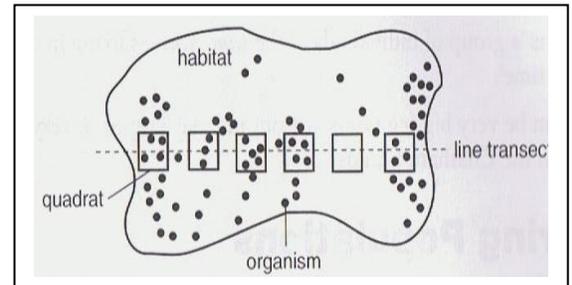
- The sample should be representative (typical) of the population.
- When measuring the population size of a particular species, two equipments are required:

1) **Transect Line**

- A line that is placed across a habitat.
- The transect line is divided up into intervals. At each interval, the population is sample.
- Transect line are most often used where the distribution of a species is affected by environmental factors, such tidal movement affecting the distribution of marine animals in rocky shore.

2) **Quadrats**

- This is a square frame used to isolate an area so that the number of organisms in that area can be counted.
- Quadrats are often used to sample areas that contain organisms which cannot move, e.g sea anemones and plants.
- Quadrats are often used to take samples along transect lines.



The following formula is used for calculating population size of a particular species.

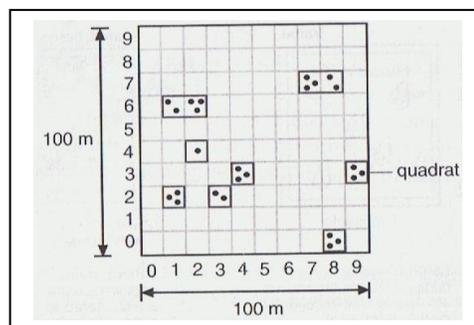
$$\text{Size of a population} = \frac{\text{area of habitat}}{\text{Area of sample}} \times \text{no. of organism in sample area}$$

Note:

- To prevent bias, a sample area must be chosen randomly - this means that the quadrats should be thrown randomly across the habitat of the population to be counted.

Example: Estimating population size

For the thistle population shown below, a quadrat measuring 5m x 5m was thrown randomly 10 times.



A total of 25 thistles were counted in the 10 quadrats.

To calculate the size of the thistle population in this area, we must use the formula given:

Size of a population = $\frac{\text{area of habitat}}{\text{Area of sample}} \times \text{number of organism in sample area}$

Total area of habitat	= 100m x 100m
	= 10,000m ²
Size of each quadrat	= 5m x 5m
	= 25m ²
Area of sample = size of quadrat x no. of quadrats	
	= 25m ² x 10
	= 250m ²

Therefore:

$$\text{Size of population} = \frac{10,000\text{m}^2}{250} \times 25$$

$$= 1000 \text{ thistles}$$

Mark and Recapture Method

- This method is used only for measuring the population size of mobile organisms.
- In this method, organisms are captured, labeled (e.g ear tags in rodents, leg bands on birds) and then released.
- Another sample is taken at a later date.
- The size of the population is then estimated using the following equation:

$\text{Size of population} = \frac{n(S_1) \times n(S_2)}{n(R)}$

where:

$n(S_1)$ = total number of organism in first sample

$n(S_2)$ = total number of organism in the second sample

$n(R)$ = number of marked animals that were recaptured in the second sample

Example: Estimating population size of rats.

40 rats were caught, tagged and released. Two months later 28 rats are captured, 14 of which were found to be tagged.

$n(S_1) = 40$ $n(S_2) = 28$ $n(R) = 14$

$\text{Size of rat population} = \frac{n(S_1) \times n(S_2)}{n(R)}$ $= \frac{40 \times 28}{14}$ $= 80 \text{ rats}$

2. Population Density

- refers to the “number of organisms present in an area.”
- It is calculated using the following formula:

$\text{Population Density} = \frac{\text{size of a population}}{\text{area of habitat}}$

Example: Consider the thistle population from the previous example:

$$\text{Population density} = \frac{\text{size of a population}}{\text{area of habitat}}$$

$$= \frac{1000}{10,000}$$

$$= 0.1 \text{ thistle per square meter}$$

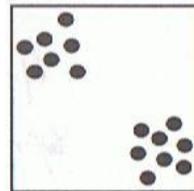
(0.1 thistle/m²)

3. Population Distribution

- Refers to how a particular species is spread out in its habitat.
- There are three important patterns observed when species are distributed in their habitat.

i) Clumped Distribution

- Members of the population are associated together into groups.

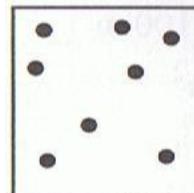


- This increases competition between individuals of each group for food and space, but usually this is far outweighed by the advantages when times are bad.

Example: slaters prevent drying out by clumping, oxen mains heat by clumping.

ii) Random Distribution

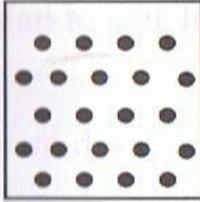
- Members of a population are randomly distributed across its habitat.



- Occurs very rarely in nature e.g distribution of some plants in the jungle.

iii) Uniform Distribution

- Members of a population are evenly spread out in its habitat.



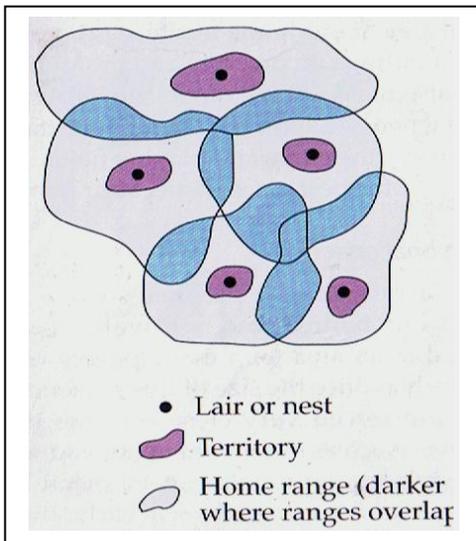
- this occurs in animals which mark out their habitat into territories for breeding e.g gulls, seals
- Plants competing for space and light also exhibit uniform distributions.
- Uniform distribution is common amongst animals in which competition or aggression keeps organisms in territories which they defend.
- The regular spacing may separate small groups or individuals; but by keeping and defending territories they ensure adequate food, nesting sites, and protection for the young and females.
- This also helps to limit a population to the density that they can be supported by the habitat.

Home range – the area that an animal covers regularly in search of food and mates.

[This area may overlap the home range of its neighbours, but it is an area that the animal gets to know well]

Territory – the area in which the animal defends and mark as its own.

[Territory are normally found inside the home range and it is usually marked with urine, faeces, special scent and glands]



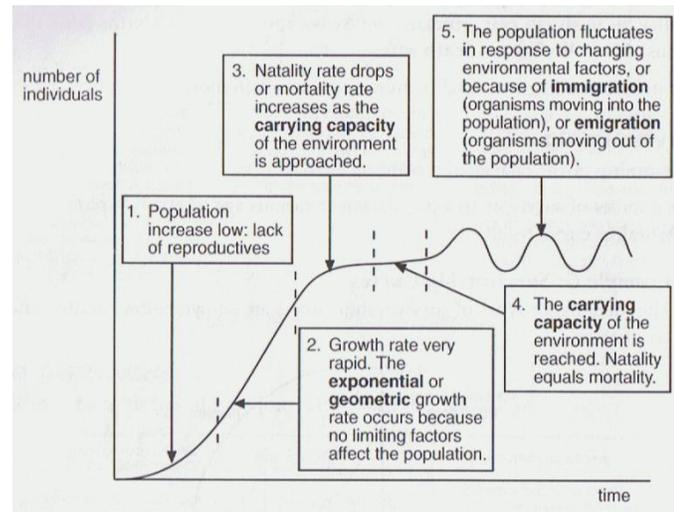
4. Population Growth

To measure the population growth, the following formula is used:

$$\text{Population Growth} = [\text{Birth} + \text{Immigration} - \text{Death} + \text{Emigration}]$$

- If a species is introduced into a new environment, the growth of the population will give a sigmoid (S-shaped) growth curve.
- Population growth can be illustrated using a Sigmoid Growth Curve or sometimes called Exponential curve.

Exponential Growth Curve



The Exponential Growth Curve has five main phases that explains how a population in a particular area grows.

Phase 1

- At this phase, population growth is very slow due to lack of reproductive pairs.
- This is illustrated by the gradient of the graph at this stage i.e not too steep. [The steeper the slop on the graph represents an increase rate of population growth].
- It also takes time before offspring produced becomes mature and fully able to produce another offspring.

Example: It takes 9 months for human to produce an offspring, thus it will take couple of years before the population can actually grow.

Phase 2

- There is sudden, quick growth during this phase due to lots of reproductive pairs; this means that there are more offspring available to produce an offspring.
- With lots of offspring able of getting pregnant, lots of offspring will be produced contributing to quick grow in the population.
- There are also lots of space available and plenty of food available for the growing population to exploit, live healthy and reproduce successfully.
- This is illustrated by the very steep slope of the graph in phase 2.

Phase 3

- Environmental resistance kicks in and population growth slows down due to:
 - ✓ Lack of space available
 - ✓ Short supply of food
 - ✓ More disease available
- The above limiting factors will decrease the growth of the population as the population becomes too big in size and the resources available become limited, therefore the growing population starts to compete for these resources.
- Those will be favoured in this competition will survive and those not favoured will die.
- This slow growth in population is illustrated by the slope of the graph at phase 3.

Phase 4

- Carrying capacity has been reached at this stage. This means the mortality = natality.

Carrying capacity - the maximum size of population able to be reached and sustained in an environment.

Phase 5

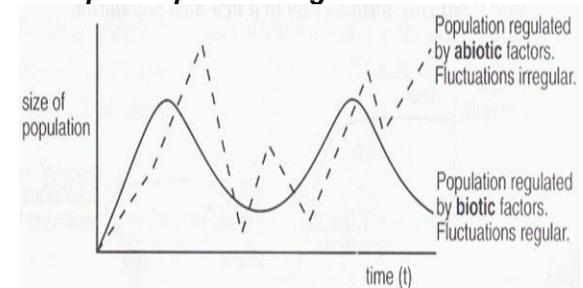
- Population starts to fluctuate due to the effect of environmental factors e.g immigration or emigration.

Note:

The human population is presently in the exponential phase of its growth. The population increase must stop as the carrying capacity of the environment is reached.

5.**Population Regulation**

- Populations are regulated by biotic (living) and abiotic (physical) factors.
 - Abiotic factors**
 - Abiotic factors affect a population regardless of its density and so are said to be density-independent.
 - Earthquakes, floods, volcanic eruptions; rainfall, temperature, humidity, soil minerals, etc usually have less dramatic effects.
 - Biotic factors**
 - Biotic factors (predation, parasitism, disease, natural wastes and competition) are density-dependent and usually affect populations in a regular predictable fashion.

Example: Population regulation**(iii) Competition**

- There are 2 types of competition among living things:

Interspecific Competition - competition for resources between **different** species.

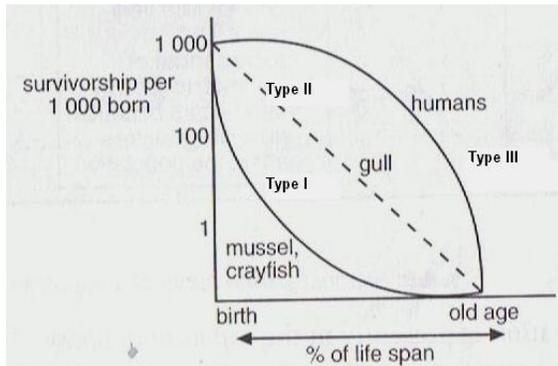
Intraspecific Competition - competition for resources between members of the **same** species.

Resources in which organisms compete for:

- ✓ Light
- ✓ Space
- ✓ Water
- ✓ Minerals
- ✓ Shelter
- ✓ Breeding sites
- ✓ Mate
- ✓ Food

6. Survivorship

- Is the “chance of remaining alive”
- If the number of survivors in a population at various age intervals is plotted, survivorship curve results.
- A survivorship curve helps us to study the number of organisms in a population that survive to any particular age (usually expressed as survivors / 1000 members of a population).
- A survivorship curve can help ecologists tell when the most members of a population will die. If possible or desirable, they can help the organisms at that time.
- The three major types of survivorship curves are shown below on the same set of axis.



Curve – Type I

- Look at Type I curve on the graph - there is a sharp drop at very young age, then the curve flattens out.
- This indicates a very high mortality during early life stages, followed by very low death rate of individual reaching adulthood.
- **Example:** turtles, oysters, bivalves.....etc
- Turtles lay eggs by the millions. Once the turtles lay these eggs, the eggs are then buried with sand on the beach. Once these eggs hatched, they swim back to the sea where some are killed by the female turtles and eat; only a few of these millions of eggs survive and make it to adulthood.

Curve – Type II

- Represents a type of population growth where the growth is constant.
- Only a small fraction of the population dies off in each time period.
- Mortality is relatively constant throughout all life stages.
- No particular age is more vulnerable than others in this type of population growth.

Example: some birds, lizards and animal.

Curve – Type III

- Look at the Type III curve on the graph and note the very high number of survivors at young age.
- The graph drops (decline) at a later age.
- This indicates a very low mortality in infant and juveniles and most of adult life.
- Mortality increases rapidly at old age.

Example: humans and other mammals.

- For humans, 100 years to 115 years is considered our lifespan, although some (or most) die at younger age.
- When human give birth, they usually give birth to one offspring at a time, and all their energies are directed into caring, feeding and protecting this offspring.
- High parental care is offered to the offspring and this explains why there is a high survival rate at infancy and juvenile years.
- In comparison, when human get into adulthood, mortality rate increases as diseases starts to kick in.

AGE STRUCTURE IN A POPULATION

In every population there are three main age groups.

1. Pre-reproductive

- This refers to the immature group of the population that are not yet able to reproduce.

Example: juveniles and young children who has not reached puberty.

2. Reproductive

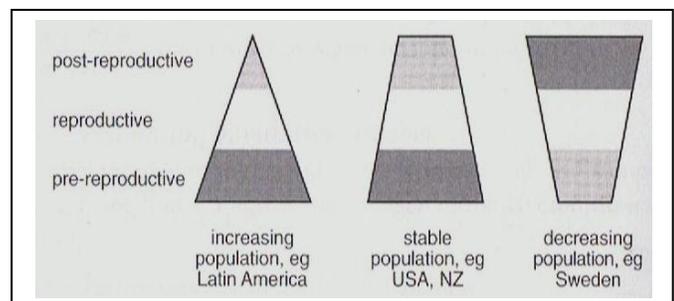
- This refers to the part of the population that has reached puberty and is fertile and is also able to reproduce.

3. Post - Reproductive

- This refers to the group of the population in which their reproductive organ has ceased to reproduce due to old age.

AGE PYRAMIDS

- In a population, information about the number of organisms alive in certain age class is displayed using age pyramids.
- The following pyramids are used to display information about a growing population.



GENETIC VARIATION OF A POPULATION

- All organisms belonging to one species or to a particular population are genetically varied.
- The variation within a population is caused by variety of factors such as:

1) Meiosis

- The production of sex cells by the process of meiosis produces gametes that are genetically different from each other.
- Since all the gametes produced by the same person are genetically different - then it means that the combination of the different gametes give rise to variation in the offspring produced.
- This explains why sisters and brothers or close relatives share similar characteristics and body features but are never exactly the same.

2) Random mating

- Most organisms mate randomly.
- Non-random mating may involve individuals selecting certain phenotype for a mate.

3) Independent Assortment

- This refers to the alignment of the homologous chromosomes randomly at the centre of the cell during metaphase I.
- When chromosomes are aligned randomly before crossing over, it implies that there is great variation in the gametes being formed.

4) Mutation

- Mutation is a permanent change to the DNA of an organism due to being exposed to mutagens.

Mutagens (Things causing mutation)

- Exposure to radioactive rays
 - Viruses
 - X-rays
 - Ultra-violet light
 - Chemicals (e.g mustard gas)
- Mutation occurs randomly in a cell but is only passed to the next generation if it occurs in sex cells.

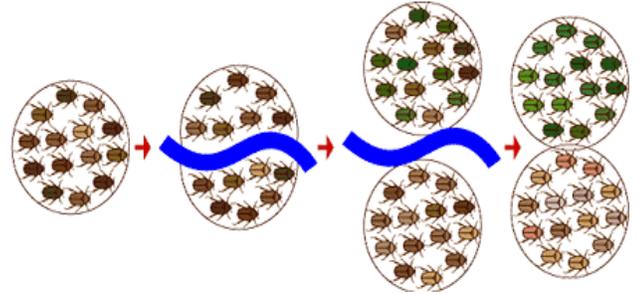
Advantage of Genetic Variation

(i) Better adaptation

- In a population that is highly genetically varied, there is greater mixture of genes and thus wider range of adaptation.
- Having a wider range of adaptation means that the population is better adapted to any change in the environment compared to a population with a narrow range of adaptation.

Speciation – the formation of a new species from a population.

- If a population is genetically isolated by geographical barriers over a long period of time - new species will be formed.
- A physical barrier reduces gene flow.



- This process is called **speciation**.

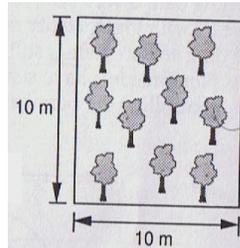
Example of geographical barriers:

- ✓ Mountains
 - ✓ Rivers
 - ✓ Oceans
 - ✓ Lakes
 - ✓ Deserts
 - ✓ Canyons
 - ✓ Ridges
- As part of a population becomes isolated geographically from the rest of the population, they can no longer interbreed with the rest of the population.
 - Being separated from the rest of the population and constant exposure to the environment where they live implies that the isolated population changes to adopt certain features or behaviours that enable them to survive in the new environment.
 - The differing environment where the original and isolated populations adapt to - means the two species will slowly change to adapt to their new environment.
 - In doing so, the once-one population have diverged to become a different species.

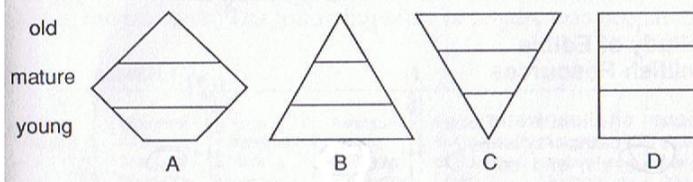
Self-check #3: Population

- A population consists of:
 - All the individuals of any kind.
 - Groups of individuals of different kinds in an area.
 - All groups of organisms in an area.
 - Individuals of the same kind in an area at a given time.
- The **quadrat** is a convenient device used in the field to:
 - Obtain measurements of the biomass of populations.
 - Help identify the species that are present in the area.
 - Obtain information about the distribution of organisms in the area.
 - Help survey and map the topography of the area studied.
- The density of shrubs is (shrubs/m², shrubs per meter square)

- 0.001 shrubs/m²
- 0.01 shrubs/m²
- 0.1 shrubs/m²
- 1 shrubs/m²

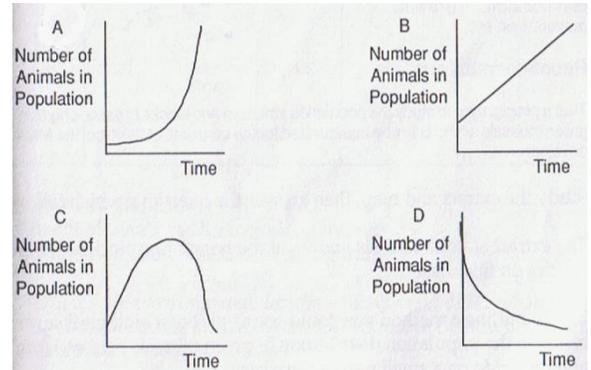


- The distribution of a species refers to:
 - The areas in which it is living.
 - How it becomes spread around.
 - The niche which it occupies
 - Where it migrates to.
- A population which is young and rapidly growing would be best represented by which one of the following pyramids:

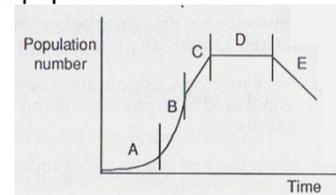


- A population of rats was set up in a sealed cage. The rat population increased. The increase was probably due to an increase in:
 - Immigration
 - Emigration
 - Survivorship
 - Natality

- The number of animals in a population depends on several factors. Which of the graphs A to D would best illustrate a situation where there are no environmental factors limiting the growth of the population?

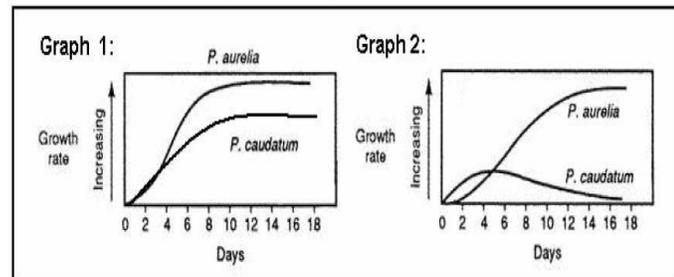


- The diagram represents a periods in the growth of an environmental population.



- During which period does some environmental factor first limit the growth of the population?
- In which period does the population reach maximum reproductive potential?

- Two species of paramecium, *Paramecium aurelia* and *Paramecium caudatum* were cultured.
 - Graph 1 shows the growth curve for the culture of paramecium grown separately.
 - Graph 2 shows the growth curves of both species when they are grown together.



- Name the type of population growth curve shown in Graph 1.
- Identify the type of competition illustrated by the two graphs.
- Suggest a possible reason why *P. aurelia* seems to be a better competitor when grown together with *P. caudatum*.
- State the ecological principle illustrated in the experiment with paramecium cultures.

10. A spider's ability to spin a web is an example of which type of adaptation?
- Structural.
 - Behavioural.
 - Reproductive.
 - Physiological.

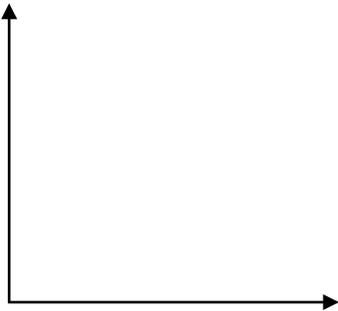
11. Define the following terms:
- Population
 - Species

12. Give TWO causes of genetic variation.

13. Five years earlier, the population was estimated to consist of 40 turtles. Assuming no migration, it is possible to conclude that over the 5 year period,
- natality equaled mortality.
 - mortality exceeded natalty.
 - natalty exceeded mortality.
 - mortality was more than natalty.

14. The number of survivors in a population at various age intervals can be plotted to obtain a 'survivorship curve'.

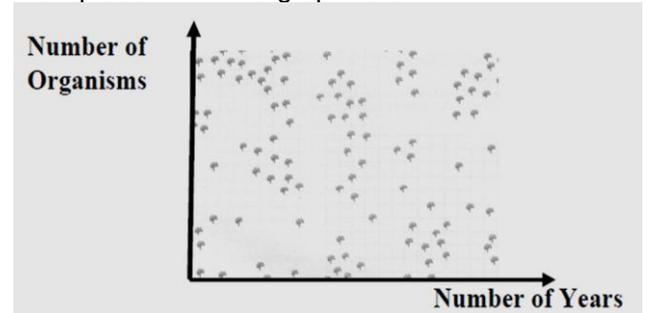
- a) On the set of axes below, draw and label TWO generalized survivorship curves, one for **humans** and the other for pelagic **fishes** which lay millions of small eggs.



- b) With reference to the survivorship curves sketched above, explain what the survivorship curves tells you about the population of fish and human.

15. A J-shaped curve represents a population that:
- Has a limited supply of food
 - Has reached point of tolerance
 - Is growing exponentially
 - Is declining rapidly

16. A group of students studied the distribution of organisms across a 10 000m² area. Their observations are represented in the graph below.



- Name the type of distribution pattern shown in the graph.
 - Name an environmental factor that is most effective in determining the arrangement shown above.
 - Describe how the density of the population can be calculating using data from the graph.
 - Sketch and label a pyramid that depicts a population that is young and growing.
17. For a new species to form from a population that is made up of two very similar subspecies, the most important requirement is
- mutation must be prevented from occurring.
 - mutation must occur in some of the individuals in the population.
 - The exchange of genes between the two subspecies must not be prevented.
 - The exchange of genes between the two subspecies must be prevented.

Week5

UNIT 4: COMMUNITIES**Learning Outcome**

At the end of this unit, students should be able to:

- Describe the characteristics of a community using examples:
 - species composition
 - patterns - zonation and stratification
 - stability - succession and climax.
- Describe the characteristics and the role of a colonising or pioneer species.
- Explain how competition for living space, food and nutrients affect relationships in a community.
- Describe the following relationships and identify an example for each: predation, parasitism, mutualism, commensalism.
- Collect and process field data to show the distribution pattern of species in a community.

Introduction

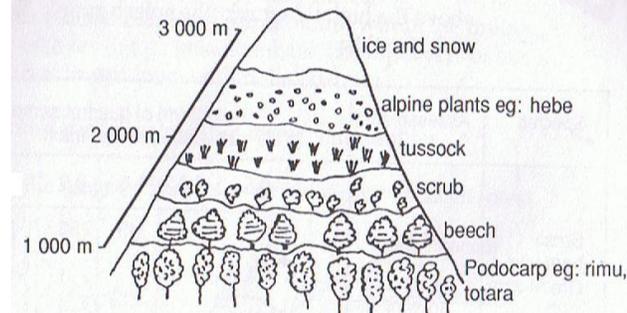
- A **community** is "all the plant and animal populations living in an area between where there is a flow of materials".
- Communities may be huge and long-lasting (like a forest in Toloa) or small and temporary (like a mosquito community).
- Communities are named after the species of greatest **biomass** (mass of living tissue), or after the most important physical feature of the environment e.g a rocky shore community, a mangrove community..etc
- Not all species and populations in a community are permanent, so communities may change.

Community Patterns

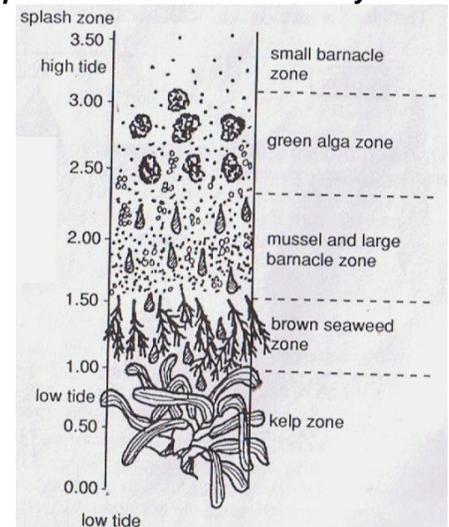
- Species are not distributed randomly across a community.
- Their distribution form patterns in response to a change in environmental conditions:
 - ☆ When species distributions fall into bands or zones across a habitat, the pattern is called **zonation**.
 - ☆ Vertical distribution into layers or strata of vegetation with plant communities form a pattern called **stratification**.
 - ☆ Changes in distribution of species with *time* is called **succession**.
 - ☆ Changes in response to seasons, day/night cycles and other *periodic* changes such as tidal changes is called **periodicity**.

(i) Zonation

- Zonation is the classification of species across a habitat into bands or zones that share unique physical characteristics, and thus each provide a unique habitat that will favour various species which will in turn exist in these zones.
- Zonation results from the *constant change* or gradient of some environmental factor across a community.
- As environmental conditions exceed the tolerance limits of a species, the zone of distribution for a species finishes.
- Another species, which is adapted to the new environmental conditions, forms another zone until it too can no longer cope with conditions.
- Competition between species where they meet means zones are usually quite distinct.

Example A: Zonation on a mountain.

The *temperature change* from the bottom of the mountain to the summit causes zonation in the plant species growing on the mountain. Moving down the mountain, competition between plants for light, space and nutrients increases markedly.

Example B: Zonation on the Rocky Shore

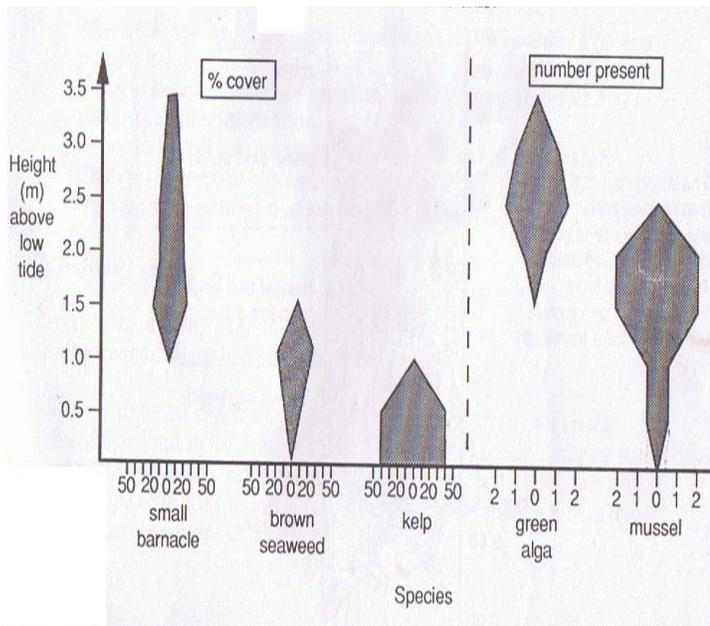
The environmental factor that causes zonation on the rocky shore is tidal movement. Competition for space and food increases as one moves down the shore from high to low tide.

Zonation distributions are often portrayed on **kite diagrams**. Kite diagrams are obtained by taking quadrat samples along a transect line across a community.

Example: For the rocky shore community illustrated in Example B, a kite diagram can be constructed using data from quadrats spaced at 0.5m vertical intervals, from the low tide mark to just above the high tide mark (the splash zone). The results might look like this:

Species	Assessment	Height (m) of quadrat sample above the low tide mark							
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Small barnacle	% cover	-	-	-	40	30	30	20	10
Green algae	Number present	-	-	-	-	1	3	2	-
Mussels	Number present	-	1	1	4	4	-	-	-
Brown seaweed	% cover	-	20	40	-	-	-	-	-
Kelp	% cover	80	80	-	-	-	-	-	-

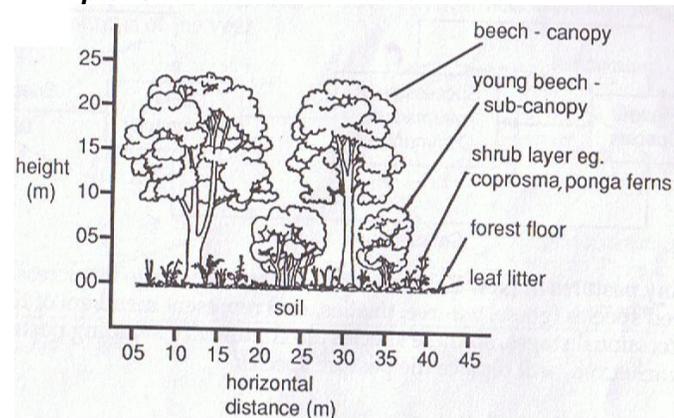
The kite diagram would look like this:



(ii) Stratification

- When plant species are distributed into strata or layers vertically in their habitat - it is called stratification.
- The vertical stratification that occurs within forests results from the varying degrees of sunlight that the different strata receive: the taller the plant and the more foliage it produces, the more light it can intercept.
- Three or more vertical strata of plants—a herb layer, a shrub layer, a small tree layer, and a canopy tree layer—often are found in a forest.
- Animals are affected by this stratification of plant life. Although they can move from one layer to another quite easily, they often adhere closely to a specific layer for foraging, breeding, or other activities.
- Stratification is most easily seen in a forest community.

Example: Stratification in a beech forest.

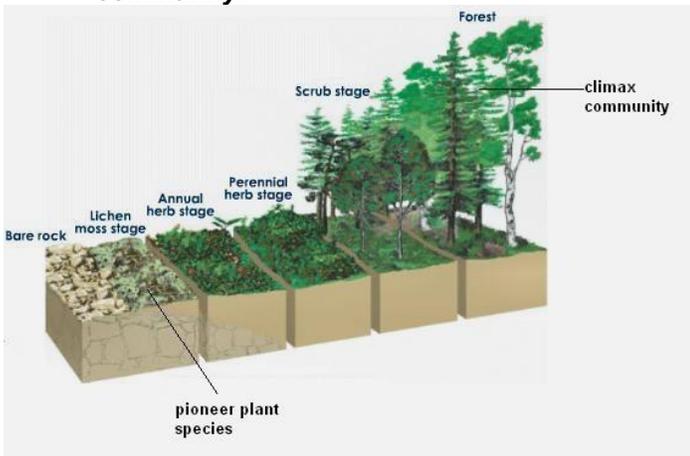


Note:

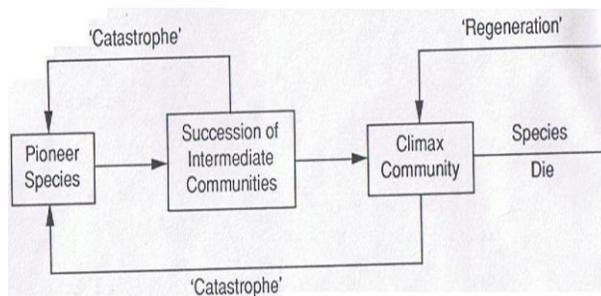
- The plants in the canopy layer receive most of the sunlight that reaches the forest.
- When moving down the vertical layers, the amount of sunlight the plants in the lower layers receive decreases as plants in the canopy layer filter out most of the sunlight.
- Plants in lower strata usually adapt to receiving less sunlight by producing darker leaves with a larger surface area.
- Having a larger surface area is one of the plant ensuring that it can trap the maximum amount of sunlight it can for photosynthesis.
- Having darker leaves due to more chlorophyll present in the leaves to aid in capturing as much sunlight for photosynthesis.
- The forest floor is always humid and it is covered with mosses, liverworts, small ferns and fungi - species adapted to high humidity and low light intensity occupy this layer.

(iii) Succession

- Succession involves a sequence of different communities within one area over a period of time.
- A gradual change in the dominant species occurs as the prevailing conditions change.
- Succession usually begins when a new habitat becomes available through a fire, landslide, flood, or other catastrophe which removes all the plants and animals.
- The first organisms to colonise the new habitat are **pioneer plant species**.
- These plant species are tolerant of exposure, desiccation, low soil fertility, etc.
- Pioneer plant species provide habitats for the first consumers by increasing soil fertility and providing shelter etc.
- The changed environmental conditions allow other species to grow up and above the pioneer species, shading them out.
- The succession of establishment, competition and replacement continues, providing a variety of distinct communities.
- The final community is called a **climax community**.



- Climax communities are stable. No further succession occurs because climax species provide the conditions necessary for the survival of their own species.

Example: Succession in a community**(iv) Community Periodicity**

- Many animals and plants can sense the time of the year and time of the day.
- They have internal clocks, which alter body rhythms, increasing activity at certain times of the year.
- These rhythmical changes in activity and behavior are classified as:
 1. **Crepuscular** - organisms that are active at twilight hours like dawn and dusk e.g rabbits.
 2. **Nocturnal** - organisms that are only active at night e.g moths, bats
 3. **Photoperiodic** - organisms that respond to day length e.g flowering and fruiting in plants, fruiting in plants and hibernation in bears.
 4. **Diurnal** - organisms that are only active at day time e.g starlings
 5. **Lunar** - organisms that are active at high or low tides only e.g crabs

COMMUNITY RELATIONSHIPS**1. Commensalism**

- A type of relationship between two species of an organism where one may benefit while the other is not affected in their interaction.

For example: Remora (suckerfish) and shark: the remora fish snatches scraps of food from the shark while the shark is feeding; the shark is unaffected.

2. Mutualism/Symbiosis

- A type of relationship between two species where both species benefit from each other during their interaction.

For example: Clownfish and sea anemones
Clownfish are frequently found in the tentacles of sea anemones, which typically capture their prey by paralyzing them with discharged cnidoblasts (nematocysts), and then ingesting the animal within the gastrovascular cavity. Studies have shown that a component of clownfish mucus *inhibits* the discharge of these cnidoblasts. The clownfish benefits by having a protected home territory.



3. Parasitism/Exploitation

- A type of relationship between two species where one species benefits while the other is harmed during their interaction.

For example: Tapeworms in human gut

The tapeworm ingest the food that human digests. The human is harmed as it is deprived of nutrients from its own diet which has been absorbed by the tapeworms. The tapeworm however benefits as it gains food and habitat as it stays in the human gut.



Endoparasites - are parasites that lives inside the body of its host e.g tapeworms

Ectoparasites - are parasites that lives outside the body of its host e.g fleas on dogs, head louse

4. Antibiosis

- A relationship in which one member of the relationship is harmed while the other member is not affected in their interaction.

For example: *Pencillium* and bacteria

The fungus *Pencillium* produces pencillin which kills bacteria. The bacteria do not affect the *Pencillium*.

The table below summarises the community relationships.

Relationship	Species A	Species B	Explanation of Association
Interspecific competition	-	-	Both species compete for the same resources
Antibiosis	0	-	Species A unaffected, B harmed.
Parasitism	+	-	Species A is a parasite on the host species B. A gains B loses.
Exploitation	+	-	Species A benefits. B harmed or destroyed
Commensalism	+	0	Species A benefits, species B unaffected
Mutualism	+	+	Both species benefit

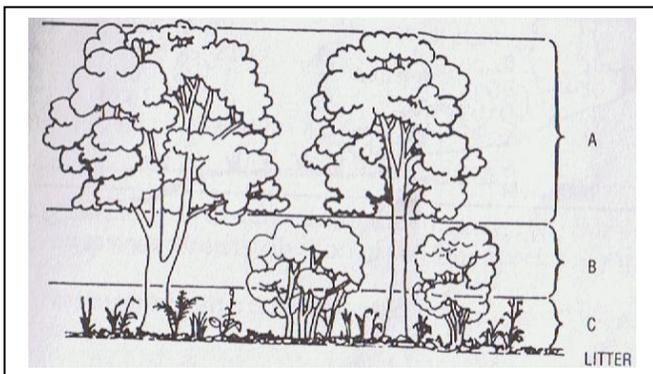
Key: + = benefits, 0 = unaffected, - = harmed

Self-check #4: Community Patterns & Relationships

- Which of the following statements describes a community?
 - A list of all species present
 - All members of a species living in an area
 - All the organisms living in an area
 - All the organisms living in an area and the environmental factors affecting them.
- In symbiosis (mutualism) two species live in:
 - Intimate dependence on each other
 - Competition for the same resources
 - Such a way that a third species is benefited
 - The same territory
- Parasitic organisms are useful if the host organism is:
 - Useful to humans
 - Killed by the parasite
 - Harmful to humans
 - A saprophyte
- A tapeworm living in a dog's gut is said to be a parasite because it:
 - Lives inside another animal
 - Damages the intestine wall with its hooks
 - Has a degenerate body form lacking eyes and legs
 - Harms the dog by using some of its food.

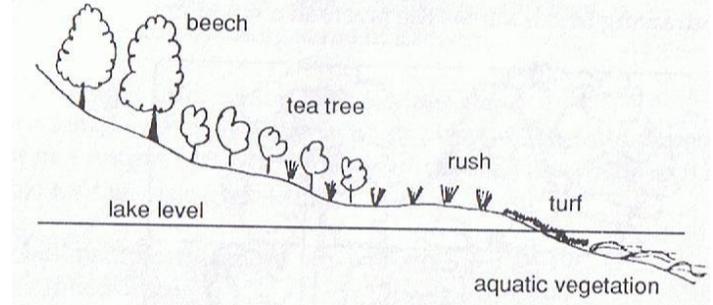
When a female wasp lay eggs in a live pine tree, she also deposits spores of a fungus that lives on and softens the wood making it suitable for the wasp grub to eat.

- The relationship between the wasp and fungus is:
 - Commensalism
 - Parasitism
 - Saprophytism
 - Symbiosis
- The relationship between the fungus and the pine tree is:
 - Commensalism
 - Saprophytism
 - Parasitism
 - Symbiosis
- The drawing below shows the layers in a woodland.



- Name the layers shown by the letters A, B and C.
- State how the light intensity in layer C differs from the light intensity in layer A during daylight.
- How might the difference in light intensity affect the plants in layer C?
- Explain how plants in layer C adapt to the difference you stated in b).
- What disadvantage might plants in layer A experience?

The diagram below shows a cross-section of the shoreline vegetation at a lake.



- This pattern of plants which exists beside the lake shore is called:
 - Zonation
 - Stratification
 - Succession
 - Hydroponics
- Scientific studies have shown that the land the tea tree now grows on was previously covered in wire rush and before the rush grew the ground was bare. This change of vegetation over a period of time is called:
 - Zonation
 - Succession
 - Stratification
 - Hydroponics
- The end-point of an ecological succession is:
 - An ecotone
 - A pioneer community
 - A climax community
 - A community unable to reproduce itself.

Week 6

UNIT 5: ECOSYSTEM

Learning Outcome

At the end of this unit, students should be able to:

- Describe, using examples, the characteristics of an ecosystem.
- Characteristics are:
- ✓ living (biotic) and non-living (abiotic)
 - ✓ food chains and food webs
 - ✓ energy flows
 - ✓ ecological pyramids (biomass, numbers, energy)
 - ✓ nutrient cycling (carbon and nitrogen)

An **ecosystem** is made up of all the living things in an area and their physical environment.

The *structure* of an ecosystem depends upon:

- i) the species present
- ii) the quality and distribution of abiotic resources, such as water and nutrients
- iii) the range of physical conditions present, such as temperature and salinity

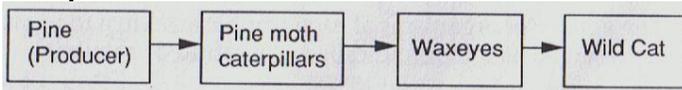
Understanding the structure of ecosystems enables resources to be more efficiently used and conserved, and artificial ecosystems, such as farms and exotic forests, to be managed more efficiently.

Ecosystems vary in size from the very small, such as the fish, snails, weeds, rocks and water of an aquarium, to the very large, such as the tropical rain forest. Together, all the ecosystems of the world make up the **biosphere**.

FOOD CHAINS, TROPHIC LEVELS AND FOOD WEBS

- A **food chain** is a chain of organism in a community through which food and energy flow.
- Food chains usually begin with **producers**.

Example:



- Each link in a food chain represents a **trophic** (feeding) level.

The trophic levels are:

- (i) **Producer** - these refers plants that provides energy for the animals in the ecosystem. Producers always occupy the first trophic level.

(ii) Herbivore or Primary (1^o) Consumers

- This refers to “plant-eaters”.
- Herbivores or primary consumers are the animals that feeds (or receives energy first-hand) from the producer.

(iii) Carnivores or Secondary (2^o) Consumers

- Refers to “meat-eaters”
- Carnivores or secondary consumers are the animals that feeds (or receives energy) indirectly from the producer i.e via the primary consumer.

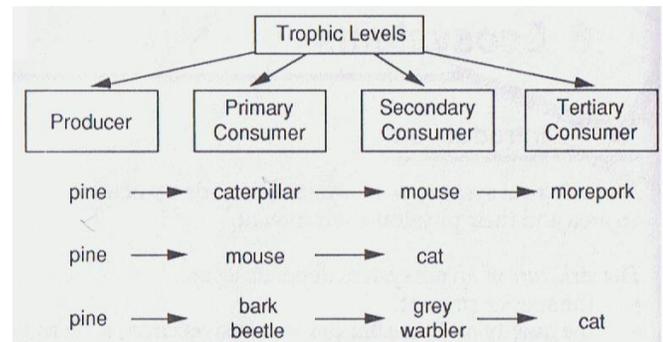
(iv) Tertiary (3^o) Consumer

- A tertiary consumer feeds off the secondary consumer.

(v) Omnivores

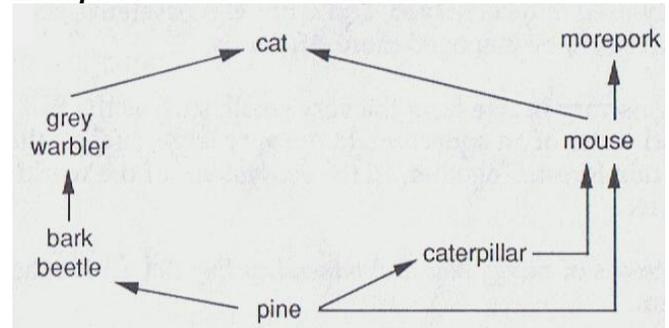
- Organisms that can be “plant-eaters” as well as “meat-eaters”

- Many food chains usually exist within a community. Species often belong to *more than one* food chain and may occupy different trophic levels in each chain.
- In the food chains from a pine forest, mice and cats occupy more than one trophic level:



- A **foodweb** can be established when the information from many food chains is put together.

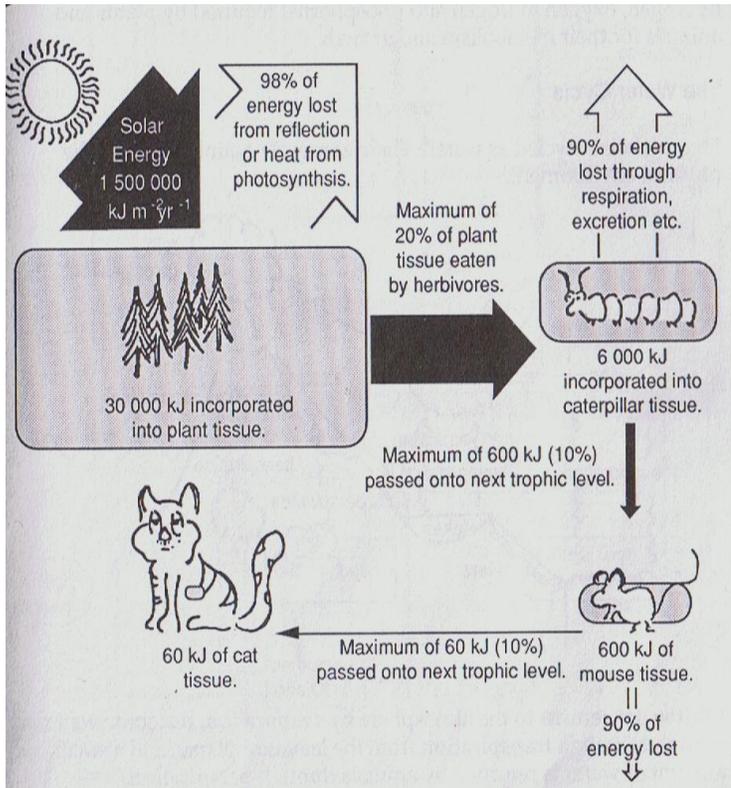
Example: Food Web of a Pine forest



- Foodwebs give a lot more detail than food chains about relationships between organisms in a community.

ENERGY FLOW IN AN ECOSYSTEM

- The process of *energy flow* determines the function of an ecosystem.



- Most of the energy at each trophic level is lost and is not passed on to the next trophic level. Approximately 90% of the energy being **lost** at each trophic level is through respiration.
- The initial 30,000kJ of energy incorporated into the pine trees has been reduced to 60kJ of cat tissue. This is only 0.2% of the 30,000kJ in plants.
- Ultimately, all the energy that enters ecosystems is lost as heat which is radiated out into space. Energy must continually re-enter ecosystems through the producers.
- Only 10% of the energy obtained at each trophic level is passed on to the next trophic level.

ECOLOGICAL PYRAMIDS

Pyramids are often used to show information regarding organisms in an ecosystem.

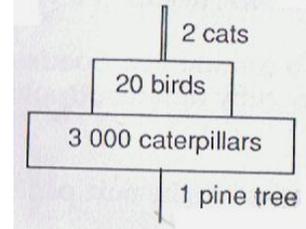
There are three types of pyramids:

- Pyramids of Numbers
- Pyramids of Biomass
- Energy Pyramids

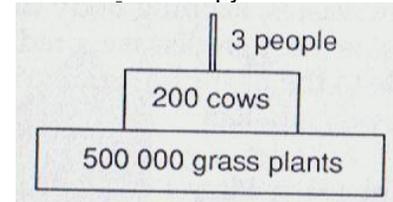
1. Pyramids of Numbers

- The *number of organisms* at each trophic level in a food chain can be represented as a pyramid called a **pyramid of numbers**.
- Pyramid of numbers can be of a variety of shapes, depending upon the producers and consumers concerned.

Example: Pine Forest Community

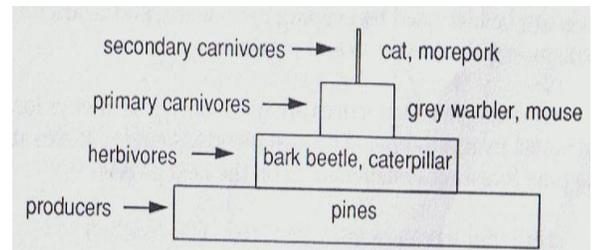


- A pyramid of numbers for a dairy farm has a shape more like that of a 'normal' pyramid.



2. Pyramids of Biomass

- Pyramids of biomass compare the mass (i.e biomass) of the species present along a food chain.
- For nearly all communities, the biomass of each trophic level is less than that of the level below.
- This loss of biomass at each level occurs because as food is eaten and digested by animals, much of the energy it contains is used for metabolism (body processes) or in growth and movement, or lost as heat.
- This means that most of the energy from the food is not passed on to the next trophic level has less food available to it, and therefore must have less biomass.
- A typical biomass pyramid, such as for the pine forest community is shown below:



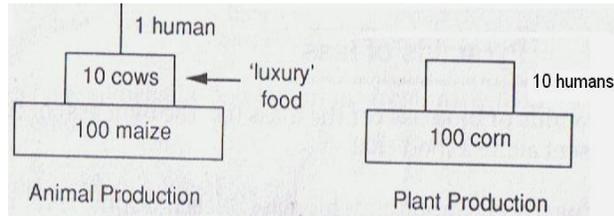
Note: The area of each 'box' represents the biomass of that trophic level.

- The units of biomass are mass per unit area (gm^{-2} , kg ha^{-1})
- In all communities, the biomass of each trophic level is less than that of the preceding level.

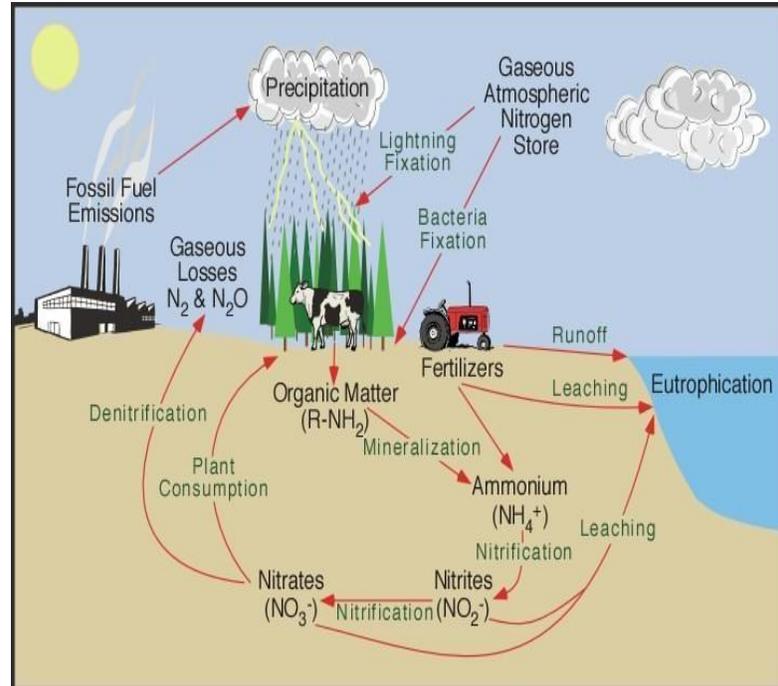
3. Energy Pyramids

- Energy pyramids are very similar to pyramids of biomass.
- Most (about 90%) of the energy at each trophic level is lost, either through heat loss from respiration, from excretion, body wastes, keeping body functions going, or from the removal of organisms through disease, predation etc.
- Because all of this energy is not available to the next ('higher') trophic level, each level of the pyramid is progressively smaller.

Example: Pyramids for Animal vs Plant Production on a farm.



- Most plants obtain the nitrogen they need as inorganic nitrate from the soil solution.
- The diagram below illustrates how nitrogen is recycled within the ecosystem.



RECYCLING OF NUTRIENTS

- Nutrients are recycled in an ecosystem.
- Although nutrients are lost at each trophic level through excretion, death or decay, they re-enter ecosystems through decomposers which breakdown the nutrients so they are made available to plants.

[In Form 6 syllabus, we will look at the recycling of only two nutrients - Nitrogen and Carbon.]

NITROGEN CYCLE

- The nitrogen cycle is the process by which nitrogen is converted between its various chemical forms.
- This transformation can be carried out via both biological and non-biological processes.
- Nitrogen is used by living organisms to produce a number of complex organic molecules like amino acids, proteins, and nucleic acids.
- Other major stores of nitrogen include organic matter in soil and the oceans.
- Despite its abundance in the atmosphere, nitrogen is often the most limiting nutrient for plant growth.
- This problem occurs because most plants can only take up nitrogen in two solid forms: ammonium ion (NH_4^+) and the ion nitrate (NO_3^-).

Important Processes involved in Nitrogen Cycle includes:

i) Nitrogen Fixation

- The process in which N_2 present in the atmosphere are converted into nitrates (NO_3^-) in soil.
- This conversion requires a lot of energy as Nitrogen is quite unreactive.
- This process can be carried out in 2 ways:
 - (i) Lightning and
 - (ii) Nitrifying bacteria present in the roots of legumes.

ii) Decomposition

- The process in which nitrogen present in dead bodies in the form of protein is converted by bacteria into ammonium ions (NH_4^+) in soil.
- The bacteria responsible for this process are called **decomposers**.

iii) Nitrification

- the process in which bacteria in soil called nitrifying bacteria converts excess ammonium ion (NH_4^+) in soil into nitrate ions (NO_3^-) to be taken up by plants again.
- The process in which plants take up nitrate ions from the soil is called **active transport**.

iv) Denitrification

- This process returns nitrogen in soil to the atmosphere by converting nitrate ions (NO_3^-) into nitrogen gas (N_2).
- Denitrifying bacteria are organisms that are responsible for converting nitrate ions into nitrogen gas.

NOTE:

- Plants take up nitrogen from soil to synthesise protein. Animals do not have the ability to take nitrogen directly from the atmosphere or take up nitrogen from soil.
- Thus, animals get their nitrogen for protein synthesis from plants through their diet.
- Some of the Nitrogen can be easily lost from the soil by **leaching** creating further environmental problems.
- Leaching and run off occurs when nitrates in the soil become dissolved in water which washes down inclined areas into the ocean.
- The additional nitrogen entering the groundwater system eventually flows into streams, rivers, lakes, and estuaries. In these systems, the added nitrogen can lead to **eutrophication**.

- Plants, animals, and soil interact to make up the basic cycles of nature.
- In the carbon cycle, plants absorb carbon dioxide from the atmosphere and use it, combined with water they get from the soil, to make the substances they need for growth. The process of **photosynthesis** incorporates the carbon atoms from carbon dioxide into sugars.
- Animals **eat** the plants and use the carbon to build their own tissues. Other animals eat other animals then use the carbon for their own needs.
- These animals return carbon dioxide into the air when they breathe (**respiration**), and when they die, since the carbon is returned to the soil during **decomposition**.
- The carbon atoms in soil may then be used in a new plant or small microorganisms.
- Ultimately, the same carbon atom can move through many organisms and even end in the same place where it began.
- Herein lies the fascination of the carbon cycle; the same atoms can be recycled for millennia!

2. CARBON CYCLE

- The Carbon Cycle is a complex series of processes through which all of the carbon atoms in existence rotate.
- The carbon cycle is the great natural recycler of carbon atoms. Unfortunately, the extent of its importance is rarely stressed enough. Without the proper functioning of the carbon cycle, every aspect of life could be changed dramatically.
- We believe that it's vital to understand how the carbon cycle works. Therefore, let's look at a sample carbon cycle and explore how carbon atoms move through our natural world.

