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### SENIOR SIX TERM 3

#### TOPIC 1/1: Ecology

**Competency:** The learner evaluates the interactions within ecosystems by analysing data and personal experiences to develop strategies for enhancing food security and promoting sustainable management of natural resources.

## Definition of ecology

Ecology is the study of the relationship of living organism with each other and their nonliving environment. The study of ecology lays a foundation for understanding agriculture, forestry, fisheries, conservation, impact of human activities on ecosystem and how to remedy these impacts.

## Ecosystem

An ecosystem is a self-sustaining unit consisting interacting organisms in area together with the non-living constituents of their environment. Example an oak wood ecosystem consists of living organisms such as trees and animals and the physical environment such as rain, the inorganic components of soil, sunlight and atmospheric oxygen and carbon dioxide.

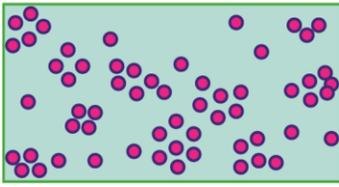
## Population

A **population** is a group of individuals of the **same species** that live in a **specific geographic area** at the **same time**, interact with each other, and can potentially reproduce to create offspring. Ecologists study population size, density, dispersion, and growth patterns (like exponential and logistic growth) to understand how populations change due to factors such as birth rates, death rates, migration, and environmental conditions.

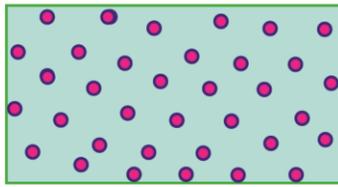
### Characteristics and Concepts of population

- **Species Specificity:** A population consists of only one species, like all the monkeys in Mabira forest or all the bacteria in a petri dish.
- **Defined Area:** The individuals must occupy a shared habitat or specific area.
- **Interactions:** Members of a population interact, for example, by competing for resources or mating.
- **Population Size (N):** The total number of individuals in a population.
- **Population Density:** The number of individuals per unit area or volume (e.g., 100 deer per square mile).
- **Dispersion/distribution:** The spatial pattern of how individuals are spaced within the area, that is,

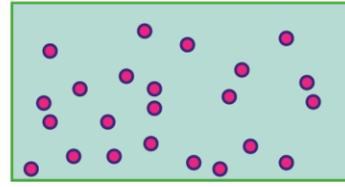
### Population dispersions



Clumped



Even/uniform



Random

- **Clumped Dispersion:** Individuals are grouped together in patches, often due to uneven resource distribution.
- **Uniform Dispersion:** Individuals are evenly spaced, which can occur due to territorial behavior.
- **Random Dispersion:** Individuals are spread out in an unpredictable manner, often indicating a lack of strong interactions among them.
- **Carrying Capacity (K):** The maximum population size that an environment can sustainably support without degrading its resources.
- **Limiting Factors:** Any biotic or abiotic factor that restricts population growth.

### Why Populations Are Studied

- **Conservation:** Identifying and protecting endangered populations.
- **Resource Management:** Managing fisheries, forests, or agricultural pests.
- **Disease Control:** Predicting outbreaks and spread of diseases.
- **Environmental Impact:** Understanding how environmental changes affect species.

### Factors Influencing Population Change

- **Birth Rate:** The rate at which new individuals are born into the population.
- **Death Rate:** The rate at which individuals die.
- **Immigration:** Individuals moving into the population.
- **Emigration:** Individuals moving out of the population.
- **Density-Dependent Factors:** Factors whose impact intensifies as population density increases, such as competition for food, disease, and predation.
- **Density-Independent Factors:** Factors that affect a population regardless of its density, like natural disasters (earthquakes, floods) or extreme weather.

## Factors affecting population size/density

### A. Biotic Factors (Living Organisms)

- **Competition:** Organisms compete for limited resources such as food, water, and shelter, which can restrict population growth.
- **Predation:** The presence and number of predators can directly decrease a prey population.
- **Disease:** Pathogens and parasites can spread through a population, leading to increased death rates.
- **Symbiosis:** Interactions like mutualism or parasitism can impact population sizes.
- **Food Availability:** An abundance of food can support population growth, while scarcity causes decline.

### B. Abiotic Factors (Non-Living Components)

- **Sunlight:** Essential for photosynthesis in plants, the source of food for the entire food web.

## Effects of light on living organism

- (i) Photosynthesis in plant
- (ii) Photoperiodic behavior in plants i.e. influence flowering in plants
- (iii) Phototropism
- (iv) Phototaxis
- (v) Vision in animals
- (vi) Migration of animals
- (vii) Reproduction

- **Temperature:** Extreme temperatures can hinder survival and reproduction.
- **Water & Moisture:** Availability and depth of water is crucial for all life.
- **Soil Conditions:** pH, salinity, texture, and nutrient levels affect plant growth.
- **Climate & Weather Events:** Natural disasters like floods, fires, and droughts can drastically reduce population sizes.

## Ecological effect of fire

- (i) kill slow animals & plants
- (ii) some animal migrates
- (iii) encourage soil erosion & leaching
- (iv) release poisonous gases
- (v) encourages regeneration in some grasses e.g. Cymbopogon
- (vi) destroys or chase away vectors, pests and parasites, e.g. tsetse flies

- (vii) accelerates nitrogen recycling of plastic waste.
- (viii) Enable vision of distant are for prey and predator.
- (ix) Allow growth of fire resistant species which are often not palatable.
- (x) Destroys humus

### Ecological effect of wind

- Occasional stormy wind can flatten trees that are 100 years old.
- Continuous strong wind can prevent trees from becoming established.
- Wind serves a useful function in the pollination and seed dispersal in plant
- Migratory birds may use winds to minimize.

### C. Population Dynamics

The number of individuals in a population is affected by four factors; birth, deaths, immigration and emigrations. The change in the size of any population over a period of time can be summed by the equation. Change in the population size = B+I- D- E where B=birth, I= immigration, D=death and E=emigration.

- **Birth Rate (Natality):** The number of new individuals born into the population.
- **Death Rate:** The number of individuals dying within the population.
- **Immigration:** The influx of individuals into a population from another area.
- **Emigration:** The departure of individuals from a population to another area.

### Environmental resistance

The form that the environmental resistance takes depends on the species in question.

Here are the main factors that limit population growth

- lack of food or water
- lack of light
- lack of oxygen
- predator and parasites
- Disease
- lack of shelter
- Accumulation of toxic waste e.g. CO<sub>2</sub> and nitrogenous waste
- stress in some case overcrowding may excess stress leading to abnormal behaviors. E.g., Female rats kept in capacity at a high population density show a breakdown in normal maternal behavior, failing to build adequate nest and abandoning their young ones.

### Habitat

A **habitat** is the specific place where a species lives and finds the food, water, cover, and space it needs to survive and reproduce

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## The ecological niche and competitive exclusion principle

An **ecological niche** is the unique functional role and position a species occupies within its ecosystem.

The **competitive exclusion** principle states that two species cannot occupy the exact same niche in the same habitat indefinitely

### Gause's experimental evidence

A classic example of this principle involved two species of the single-celled microorganism *Paramecium*:

- **Separate cultures:** When grown in separate test tubes with a fixed amount of nutrients, both *Paramecium aurelia* and *Paramecium caudatum* thrived.
- **Combined culture:** When placed together in the same test tube, *P. aurelia* outcompeted *P. caudatum* for food, eventually leading to the extinction of *P. caudatum*.

### Difference between Habitat and Niche

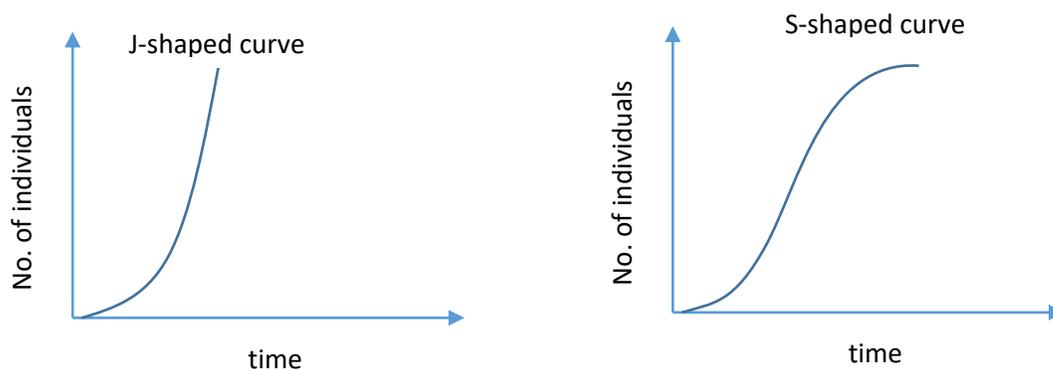
The table below shows the main difference between habitat and niche:

Habitat	Niche
A habitat is a particular place where organisms live, i.e. address.	A niche defines a specific role played by organisms in an ecosystem, i.e. profession.
Habitat is not species-specific, and many species can occupy the same habitat.	Niche is species-specific, and it supports only a single species.
Habitat consists of several niches.	Niche is specific to a particular species, which may overlap with a similar niche but must have distinct differences.
Habitat is a superset of niche.	Niche is a subset of habitat.
Examples: desert, ocean, mountains, grassland, forest, etc.	Examples: different trophic positions occupied by Darwin's finches.

## Population growth and growth curves

Populations grow and decline in characteristic ways. The size of population increase will be determined by the reproductive potential of the organism concerned and by environmental resistance. A Plot of the number of individuals against time form a growth curve.

Two basic forms of growth curves can be identified by the J-shaped growth curve and the S-shaped or sigmoid growth curves.



The S- shaped or sigmoid growth describes a situation in a new environment:

- initially the population density of an organism increases slowly because there is a shortage of reproducing individual which may be widely dispersed as it adapts to new conditions and establishes itself;
- then increases rapidly, approaching an exponential growth rate. During this growth phase there are optimal environmental conditions- No environmental resistance, birth rate exceeds death rate.
- It then shows a declining rate of increase until a zero-population growth rate is achieved where the reproduction (natality) equals rate of death (mortality), The declining rate of increase reflects increasing environmental resistance, which become proportionately more important at higher population densities. In other words, as the number increase, the competition for essential resource such as food or nesting materials, increases until eventually feedback in terms of increase mortality and reproduction failure [fewer mating, stress induced abortion] reduces population growth to zero with natality and mortality in approximate equilibrium.

The J-shaped growth curve describes a situation in which, after initial establish phase (lag phase) population growth continues in an exponential form until stopped abruptly, as environmental resistance becomes suddenly effective. In very general terms the J- shaped growth form may be considered an incomplete sigmoid curve where a sudden limiting effect

(flood, fire, disease) comes into play before the self-limiting effect within the population assume importance.

The maximum population of an organism that a particular environment can sustain is termed the **carrying capacity**. This is identified theoretically as the  $K$ -value [or upper asymptote] of the sigmoid curve

## Population size

### How to estimate population size

- (i) The population size of large animals living in unconcealed habitats, e.g. Antelopes, Hippopotami, lions etc. can be determined by direct counting methods which include
- (ii) direct counting of large organisms that are not aggressive and are living in open habitat e.g. cattle, buffaloes, Elephants and trees in the forest are counted one by one.
- (iii) direct counting of animals from low flying aircraft
- (iv) taking aerial photographs and counting animals in the photographs
- (v) driving animals to a particular spot and then count one by one
- (vi) Strip **census where** animals are counted a long path while walking or in a slow moving vehicle. The population density of an area is determined as the number per unit area (of strips)

### Advantage of direct counting methods

- Quick and accurate
- More than one population can be estimated at the same time
- Other aspects of organism ecology, behavior can be taken at the same time.
- There is minimal disturbance to environment.

### Disadvantage of direct counting methods

- It may be difficult to count overcrowded organisms, e.g. flock of weaverbird or buffaloes.
- Some organisms avoid being seen.
- Difficult to use on animals that concealed in their habitat.
- Bad weather may affect visibility and hence the count.
- Does not take into account the immigrants or emigration
- Tedious

## Methods of determining the population of small animals

### Quadrat method of estimating population size

The quadrat method is a sampling technique used to **estimate the size and density of immobile or slow-moving populations**, like plants, by counting individuals within several randomly or systematically placed square areas (quadrats) of known size. The average count per quadrat is then used to **extrapolate the total population size** across a larger, defined habitat by multiplying it by the total number of quadrat-sized areas within that habitat.

## How the Quadrat Method Works

- (i) **Define the Study Area** Determine the total area (A) you want to study.
- (ii) **Establish Quadrat Size:** Choose a quadrat of a known size (a), often 1m<sup>2</sup> square.
- (iii) **Place Quadrats:** Randomly or systematically place multiple quadrats within the habitat.
- (iv) **Count Individuals:** Within each quadrat, count the number of target organisms (n).
- (v) **Edge Rule:** If an organism is on the edge, count it only if more than half of it is inside the quadrat boundary.
- (vi) **Calculate Average Density:** Determine the average number of individuals per quadrat (n).
- (vii) **Estimate Total Population:** Use the formula:  $N = (A/a) \times n$ , where

N = Estimated total population size, A = Total area of the habitat, a = Area of one quadrat and n = Average number of individuals per quadrat

- (viii) **Species density** =  $N/A$

## Suitability of quadrat method

- **Plants:** Most suitable for stationary plants.
- **Immobile or Slow-Moving Organisms:** Good for small invertebrates or slow-moving animals.
- **Large Habitats:** Useful for estimating populations over vast areas.

## Advantages of quadrat method

- **Simple and Inexpensive** since it requires minimal equipment.
- It reduces the chances of counting same individual twice
- It is **possible** to estimate population of more than one species at the same time
- **Effective** for sessile or slow-moving species.

## Disadvantages of quadrat method

- Can be inaccurate for fast-moving animals that can enter and exit quadrats.
- Assumes even distribution; may not reflect clumping or patchy distribution well.
- May miss organisms that are buried or too sparse.

### Capture – recapture or mark-release method of estimating population size

The capture-recapture (or mark-release-recapture) method estimates a population's size by **capturing, marking, and releasing a sample of animals**, then **recapturing a second sample** to see what proportion is marked. The proportion of marked individuals in the second sample indicates the proportion in the total population, allowing an estimate of total population size ( $N$ ) using the Lincoln-Petersen Index formula:

$$N = \frac{n_1 \times n_2}{m_2}$$

where

$N$  = Estimated total population size

$n_1$  = is the first sample size,

$n_2$  = is the second sample size, and

$m_2$  = is the number of marked individuals in the second sample.

### How the capture –recapture method works

1. **Capture and Mark:** A known number of individuals ( $n_1$ ) are captured, marked with a harmless, identifiable tag (e.g., band, paint), and released back into the population.
2. **Recapture:** After allowing time for the marked individuals to mix randomly with the unmarked population, a second sample ( $n_2$ ) is captured.
3. **Count Recaptures:** The number of marked individuals ( $m_2$ ) in the second sample is counted.
4. **Estimate Population Size:** The ratio of marked to unmarked animals in the second sample is used to estimate the total population size ( $N$ ).

### The Lincoln-Petersen Index Formula

A common formula for two capture sessions is:

$$N = \frac{n_1 \times n_2}{m_2}$$

where

$N$  = Estimated total population size

$n_1$  = is the first sample size,

$n_2$  = is the second sample size, and

$m_2$  = is the number of marked individuals in the second sample.

### Example

240 flamingos are caught, marked, and released ( $n_1=240$ ). The next day, 200 flamingos are caught ( $n_2=200$ ), and 40 have marks ( $m_2=40$ ). Find the total population.

$$N = \frac{n_1 \times n_2}{m_2} = \frac{240 \times 200}{40} = 1,200$$

The estimated total flamingo population is 1,200.

### Key Assumptions/precautions of capture-recapture method

The accuracy of the estimate depends on several key assumptions:

- **Closed Population:** No significant births, deaths, immigration, or emigration occur between captures.
- **Random Mixing:** Marked individuals mix randomly and completely with the unmarked population.
- **Mark Durability & Visibility:** Marks are not lost, do not harm the animal, and do not affect its survival or likelihood of being recaptured.
- **Equal Catchability:** All individuals, marked or unmarked, have an equal chance of being captured in the second sample.

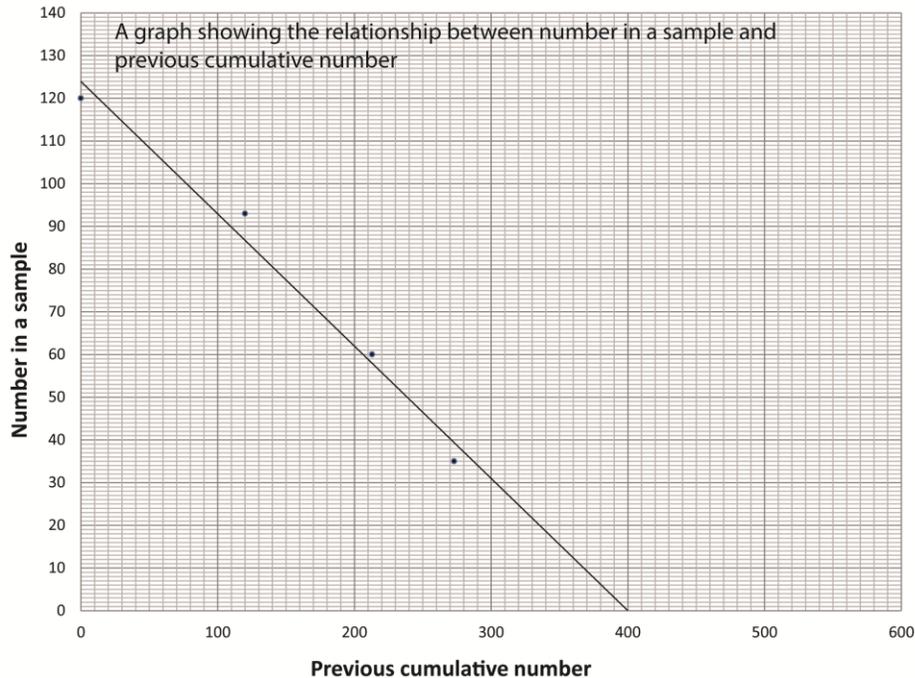
### Uses of capture –recapture method

This method is essential for studying animals that are difficult to count directly, such as those with large populations, secretive behaviors, or those inhabiting complex environments.

### Removal method of estimating population size

The removal method is very suitable for estimating number of small organism particularly insects, within a known area of grass land or volume of water. Using a net in some form of standard sweep; the number animals is recorded and the animal kept. This procedure is repeated a further three times and gradually reducing number recorded. A graph is plotted of number of animal captured per sample against the previous cumulative number of animal captured. By extra plotting the time of the graph to the point at which no further animal would be captured (that is the number in sample = 0) The total population may be estimated, e.g.

Sample	number in Sample	cumulative sample size
1	120	0
2	93	120
3	60	213
4	35	273



From the graph the estimated number organisms is = 400

The **Removal Method** estimates population size by **repeatedly sampling and removing individuals** from a closed population, observing a **decreasing catch in subsequent samples**, and using this trend to project the original total size. Key assumptions include a **constant population** (no births, deaths, and migration), **equal capture probability** for all individuals and **same capture effort** across sampling periods. The method works by plotting catches against accumulated removals to find a regression line that extrapolates to the x-axis, estimating the initial population.

#### **Advantages**

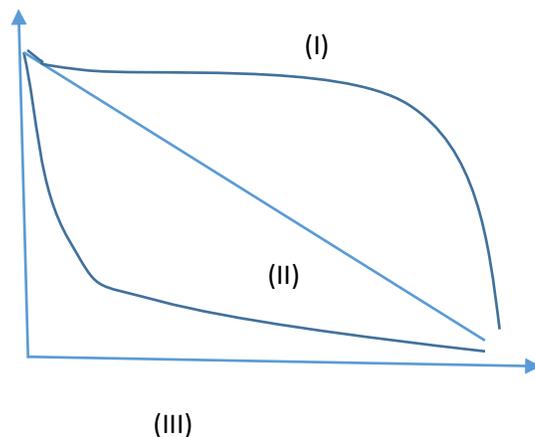
- Effective for **highly motile animals** that are difficult to see in their habitat.
- Can provide a **100% count** in theory if sampling continues until no more individuals are caught.

#### **Disadvantages**

- Requires holding individuals out of the population, which can disturb it.
- Practical difficulties can arise, similar to mark-recapture methods.
- Assumes a closed population, which can be restrictive.

## Survivorship curves

Ignoring for the moment immigration and emigration, birth and death are the two processes which affects population size. However, these processes depend on the age of individuals and on their sex. The crucial factor is the chance of an individual has of surviving to a given age, This can be shown by means of survivorship curve, To understand a survivorship curve, image a population of 100 individuals borne at the same time. The curve shows how many of them are likely to be alive at any particular age. There are three main types of survivorship curve and these are shown below;



Curve (I) is typical of organism such as ourselves that have few young ones. After an initial period of low juvenile mortality, mortality is very low until late in life

Curve (II) is found in many small birds, notice that as the vertical axis is logarithmic, the curve actually shows an exponential decline in the number of individual surviving overtime. The individuals do not die of old that is, there is no senescence.

Curve III The lower curve is typical of many plants and fish. Thousands or millions of young are produced, few of which mature into adults. The vast majority die as juveniles.

### Abiotic and Biotic environment

Abiotic/Physical environment of an organism is the sum of the entire non-living factor that influence that organism such as climate, soil and topography. While the biotic environment of an organism, on the other hand, is the sum of living factor that influence the organism.

For instance, the biotic factors a goat are other goats it interacts with, plants it feed on, the mites, tick, flies and other parasites that bother it, the soil organism that will decompose her body when she dies, etc.

## Association between species

There are many situations in which organism form close associate with one another. Such associations may occur with the same species [intraspecific associate] or between different species interspecific influenced by the presence of the other.

Intraspecific association, such as communication, mating behavior, form the basis of social organization.

### Intimate associations

Intimate organism associations are known as symbiosis, a close and long-term biological interaction between different species. These relationships can be categorized by the effect each partner has on the other.

### Types of symbiotic relationships

#### Mutualism

In mutualism, both organisms in the association benefit.

#### Examples

- (vii) **Lichen** is an association between a fungus and an alga. The fungus absorbs water from atmosphere while an alga photosynthesizes for both.
- (viii) **Termites and gut protozoa**: Termites are unable to digest wood on their own. They rely on single-celled protozoans living in their gut to break down the cellulose. The protozoa gain a safe home, and the termites gain essential nutrients.
- (ix) **Corals and alga, zooxanthellae**: Reef-building corals have a mutualistic relationship with photosynthetic dinoflagellates called zooxanthellae. The algae live in the coral's tissues, receiving protection and waste products like carbon dioxide, while the coral receives oxygen and nutrients from the algae's photosynthesis.
- (x) **Clownfish and sea anemones**: The clownfish is protected from predators by living among the stinging tentacles of a sea anemone. The clownfish, in turn, defends the anemone from its own predators.

### Endosymbiosis

In some symbiotic relationships, one organism lives inside the other, a condition known as endosymbiosis. The most striking example is the origin of eukaryotic cells.

- **Mitochondria and chloroplasts:** According to the endosymbiotic theory, the mitochondria and chloroplasts found in eukaryotic cells originated as free-living bacteria that were engulfed by a host cell. These organelles now live as crucial "powerhouses" and "food factories" inside their host cells.

## Commensalism

In commensalism, one organism benefits while the other is neither helped nor harmed.

### Examples

- (i) **Remoras and sharks:** Remoras are fish that attach to sharks and other large marine animals. They eat leftover food and receive transportation without affecting the shark.
- (ii) **Epiphytic plants:** These plants, such as many orchids, grow on the surface of other plants for support. They do not take nutrients from their host but benefit from being closer to sunlight.
- (iii) **Hermit crabs and gastropod shells:** Hermit crabs use discarded shells for protection. The original shell owner is dead, so it is unaffected by the relationship.

## Parasitism

In parasitism, one organism (the parasite) benefits at the expense of the other (the host).

### Examples

- (i) **Tapeworms:** An adult tapeworm lives in the intestinal tract of a vertebrate host, absorbing nutrients from the host's food. In high numbers, it can cause malnutrition or disease.
- (ii) **Malaria and mosquitoes:** The malarial parasite infects a mosquito, which then acts as a vector, spreading the disease to other animals, including humans.
- (iii) **Ticks and mammals:** Ticks attach to mammals to feed on their blood, potentially transmitting diseases in the process.

## Challenges faced by a parasite

- (i) Locating a new host
- (ii) Overcoming host rejection
- (iii) Entering a host

## Parasitic adaptations

Parasites show many different adaptations of overcoming these challenges, depending on whether they are ecto-parasites or endo-parasites.

## Morphological and anatomical adaptations

- (i) **Attachment structures:** Parasites use hooks, suckers, and other adhesive organs to firmly attach themselves to the host's tissues, preventing them from being dislodged by host movements or digestive processes; e.g. tape worm
- (ii) **Loss of unnecessary organs:** Many parasites lose complex organs that are not needed for their lifestyle, such as a digestive system (instead absorbing nutrients directly through their body surface) or sense organs (since the host environment is relatively stable)e.g. tape worm
- (iii) **Body shape:** Some parasites develop flattened or elongated bodies to fit into narrow spaces within the host e.g. flukes, ticks etc.
- (iv) **Protective coverings:** Many have a protective outer layer to shield them from the host's digestive enzymes and immune system.
- (v) **Penetrative devices:** for gaining entrance into the host and its cells. For example, miracidum larva of the liver fluke, has a slender tip on to which open a group of glands which secrete tissue- digesting enzymes. By softening the tissue, the enzyme enables the larva to bore into the foot of a freshwater snail the intermediate host.

## Physiological and reproductive adaptations

- (vi) **High reproductive capacity:** To overcome the low probability of a new host being found, parasites often have a very high reproductive rate, producing large numbers of eggs or offspring.
- (vii) **Anaerobic respiration:** They can often respire in low-oxygen environments, which is crucial for parasites living in the host's gut or other tissues where oxygen is scarce.
- (viii) **Nutrient absorption:** They have evolved efficient ways to absorb pre-digested nutrients directly from the host's body fluids or tissues.
- (ix) **Defense mechanisms:** Some parasites secrete anti-enzymes to neutralize the host's digestive juices or manipulate the host's physiology to create a more suitable environment, such as a protective mucus layer. Another example is the blood fluke, schistosoma, that cause, bilharzia, synthesizes chemicals, which switch of the host's immune system; The parasite coat's itself with molecules which the host recognizes as self.
- (x) The parasites may have a **dormant resistant stage** in its life cycle to survive adverse conditions until a suitable host is found.

## Behavioral adaptations

- (xi) **Co-evolution:** Over long periods, a parasite may evolve to be less harmful to its host, as a dead host is of no use to the parasite. The host also evolves to cope with the parasite.
- (xii) **Host switching:** Some parasites can switch to a different host species if the primary host becomes inactive, such as during winter hibernation.
- (xiii) Parasite overcome a problem of moving from one host to another by a number of strategies, one of which is to wait until the host mates. The various organism responsible for sexually transmitted diseases in human spread in the same manner or use secondary hosts.

### The spectrum of intimate associations

Symbiotic relationships are not always fixed and can be seen as existing along a continuum.

- **Obligate vs. facultative:** A relationship can be obligate, meaning one or both partners are completely dependent on the other for survival. Or it can be facultative, meaning they can live independently.
- **Dynamic nature:** The nature of a symbiotic relationship can change over time. Environmental shifts, changes in population density, or evolutionary pressures can cause a mutualistic relationship to become commensal, or a commensal one to become parasitic.

### Predation

In this relationship in which one organism lives the other dies instantly. For example lion the predator kills the zebra (prey) instantly.

### Ways by which animals avoid predation/predators

- Confusing the predator. For example, a covey (small flock of bird) of bobwhite suddenly emerging out of a roost startles a fox and a hawk so much that it is unable to single out one of the birds to pursue.
- Snakes, bees, spiders and other organisms bite and inject deadly poisons into the predators
- Poison dart frog, rough-skinned salamander and millipedes produce poisonous substances on their skins that scare away predators
- Porcupines use spines to pierce and scare predators
- Fast and zigzag running/flying is used by flying insects and rabbits to escape predators.
- Some animals such as chameleon camouflage with environment to hide from predators
- Animals like tortoise and snail hide themselves in hard shells.
- Some animals resemble dangerous animals (mimicry) to scare away predator e.g. Coral snakes mimic venomous king snakes.
- Some animals like bull snakes, ravens produce startling sound.
- Some are animals such opossums move at night to avoid predators.

## Succession

Ecological succession is the gradual process of change in community's species composition over time, following a disturbance or colonization of a new habitat.

This process is characterized by a series of intermediate stages, called seral stages, that progress toward a more stable "climax community" or are interrupted by new disturbances.

### Types of succession

- (i) **Primary succession:** Begins in a barren area with no life, such as newly formed rock or a lava flow. Pioneer species, like lichens and mosses, colonize first, breaking down rock and creating soil. Over time, the soil supports more complex life, leading to a progression of plants and animals. It must be noted that the first organisms to colonize a bare rock must be photosynthetic.
- (ii) **Secondary succession:** Occurs in an area that has been disturbed but still has soil. Examples of disturbances include wildfires, floods, or logging. Grasses and other herbaceous plants grow first, followed by shrubs and then trees, as the ecosystem recovers.

### Characteristics of succession

- (i) **Changes over time:** The mix of species and the structure of the ecosystem change over a period of time.
- (ii) **Progression:** Succession typically progresses towards a more complex and diverse system.
- (iii) **Pioneer species:** The process is initiated by pioneer species, which are adapted to colonize harsh conditions.
- (iv) **Habitat modification:** Each stage of species modifies the habitat, creating conditions that allow for new, different species to move in and outcompete the previous ones.
- (v) **Climax community:** The process is traditionally thought to end in a climax community, which is a stable, self-sustaining community in equilibrium with its environment.

### The role of primary succession in preserving biodiversity

- **Foundation for Life:** It's the initial process that allows life to take hold in seemingly lifeless areas.

- **Soil formation:** As pioneers die and decompose, they enrich the bare rock with organic material, gradually forming primitive soil.
- **Habitat creation:** It's a continuous process of building and diversifying habitats, supporting a greater range of species over time.
- **Nutrient cycling enhancement:** Pioneer species convert unavailable nutrients into usable forms, fueling further growth and diversification.
- **Ecosystem complexity:** It leads to more complex food webs and greater species richness, which are key indicators of a healthy, resilient ecosystem.

### The role of secondary succession in preserving biodiversity

- **Restores ecosystems and habitats.** Following disturbances like wildfires, floods, or agricultural abandonment, secondary succession enables a community of species to recolonize and rebuild. By restoring the physical structure and function of an ecosystem, it ensures that diverse wildlife can return and thrive.
- **Promotes habitat and species diversity.** As secondary succession progresses through different stages, it creates a variety of habitats, from early-stage open fields with pioneer species to mid-stage shrub-lands and late-stage mature forests. This mix of habitats provides for a wider range of species than a single, uniform environment could support.
- **Recovers genetic diversity.** Disturbances can wipe out or reduce populations of certain species. However, surviving seeds in the soil ("seed banks"), root systems, and nearby ecosystems can aid the rapid reintroduction of diverse genetic material, allowing populations to recover more quickly.
- **Enhances ecosystem resilience.** By enabling ecosystems to bounce back from natural and human-caused disruptions, secondary succession is a key mechanism for maintaining stability and resilience in the face of change. A diverse ecosystem is generally more resilient to future disturbances.

## Degraded ecosystems

Degraded ecosystems are environments significantly **diminished in quality and function** due to human activities and natural disasters, leading to losses in biodiversity, soil fertility, water resources, and essential ecosystem services like pollination and carbon sequestration.

### Characteristics of Degraded Ecosystems

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- (i) **Reduced Biodiversity:** Loss of plant and animal species.
- (ii) **Poor Soil Health:** Erosion, reduced fertility, and loss of organic matter.
- (iii) **Water Scarcity & Pollution:** Depletion of freshwater sources and contamination.
- (iv) **Disrupted Nutrient Cycles:** Impaired processes of nutrient cycling and detoxification.
- (v) **Loss of Ecosystem Services:** Diminished capacity to provide clean air, water, and fertile soil.

### Common Causes of Degradation of ecosystem

- (i) **Deforestation:** Clearing forests for agriculture or development.
- (ii) **Unsustainable Agriculture:** Overuse of pesticides, intensive farming, and poor land management.
- (iii) **Overgrazing:** Excessive livestock grazing that damages vegetation and soil.
- (iv) **Pollution:** Contamination of soil and water from industrial and human sources.
- (v) **Urban Expansion:** Development consuming natural habitats.
- (vi) **Climate Change:** Intensifying impacts on ecosystems.

### Impacts of Degradation of ecosystems

- (i) **Threat to Food Security:** Loss of arable land and productive agricultural systems.
- (ii) **Increased Climate Vulnerability:** Reduced capacity for ecosystems to absorb carbon.
- (iii) **Economic Losses:** Decreased natural resource availability and increased disaster risks.
- (iv) **Human Health Issues:** Exposure to pollution and reduced access to clean resources.

### Techniques restoring degraded ecosystems

- (i) **Reforestation & Afforestation:** Planting trees to rebuild forest ecosystems.
- (ii) **Sustainable Land Management:** Practices like regenerative agriculture and responsible grazing.
- (iii) **Soil and water management practices** such as use of fertilizers, control soil erosion, irrigation
- (iv) **Microbial Technologies:** Using microbes to detoxify soil and enhance nutrient cycles.
- (v) **Species Reintroduction:** Bringing back native species that were lost from the ecosystem.
- (vi) **Enrichment Planting:** Adding desired species to support natural regeneration.
- (vii) **Invasive Species Removal:** Controlling or eradicating non-native species that outcompete native ones.

## Benefits for restoring degraded ecosystems.

### Environmental benefits

- (i) **Climate change mitigation:** Restored forests, wetlands, and peatlands absorb carbon dioxide from air and reduce likelihood of global warming.
- (ii) Restoration is crucial for reversing the loss of habitat and the unprecedented rate of species extinction.
- (iii) **Improved water quality and supply:** Healthy ecosystems, such as forests and wetlands, act as natural water filters.
- (iv) **Enhanced soil health:** Restoring degraded land improves soil quality and fertility, which is critical for supporting plant life and preventing erosion. Healthier soil leads to increased agricultural productivity and reduces the risk of desertification.
- (v) **Protection against natural disasters:** Restored coastal wetlands, mangroves, and floodplains act as natural buffers against extreme weather events like storm surges and floods. Restoring vegetation in arid areas also helps reduce the impact of droughts and dust storms.

### Economic benefits

- (i) Restoration activities such as planting trees, managing invasive species, and restoring waterways, create "green jobs" in areas like ecological engineering, sustainable agriculture, and ecotourism.
- (ii) Restoring ecosystems helps avoid these costs by preventing damages from flooding, drought, and agricultural losses.
- (iii) Restoration of soil fertility increases agricultural output and high return on investment

### Social benefits

- (iv) Improved food security from increased food production
- (v) **Poverty reduction** by increasing the productivity of land and creating jobs.
- (vi) **Better human health and well-being** by restoration of clean air and water which lead reduced prevalence of diseases.

## Cycling of matter and energy flow in ecosystem

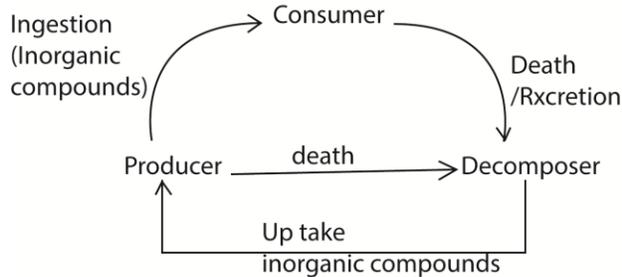
In almost all ecosystem, the organisms fall into three nutritional groups.

- producers
- Consumers
- Decomposers

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These are related as follows;

### Cycling of matter



Organic material synthesized by the produces are eaten and assimilated by the consumers, All the organic materials incorporated into the bodies of the consumers are eventually broken down into inorganic materials. These are then rebuilt into organic compound by the synthesis activity of the producers once again.

### Food chain

A food chain is a sequence of organisms with arrows pointing from organisms being eaten to organism that eats it.

Grass → Grasshoppers → Chicken → Man

Each stage of the food chain is known as a **trophic level**, the first trophic level being occupied by **the autotrophic organisms**, the primary producers. The organism of the second trophic level are called primary consumer, those of the third level are secondary consumer and so on. There are usually four or five trophic levels and seldom more than six because;

- There simply not enough energy in ecosystem to support more than this number of steps. As it is, top carnivores often have to roam over huge area to find enough food.
- It is difficult to imagine a species with the hunting abilities necessary to feed on eagles, loins, killer whales or any other existing top carnivores,
- The more levels in food chain the less stable it becomes.

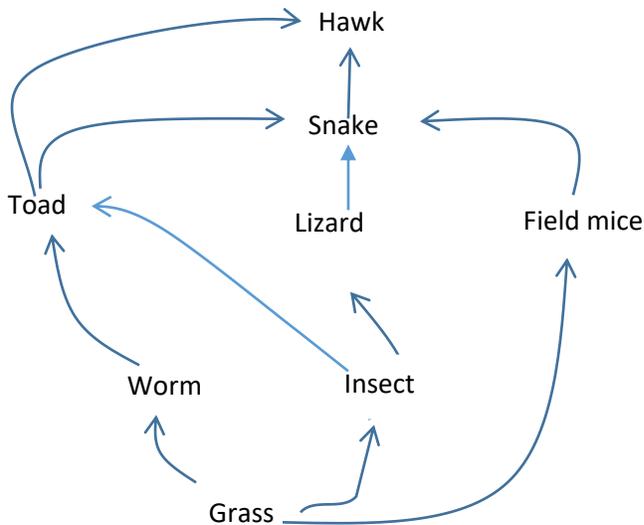
### Energy flow in ecosystem

Energy flow in an ecosystem describes the movement of energy from one feeding level (trophic level) to the next, starting with producers and moving up the food chain. Unlike nutrients, which are recycled, energy flows through an ecosystem in a one-way direction and is not reused.

## Food webs

Is feeding relationship showing organisms feeding on more than one organisms.

Example of a food web

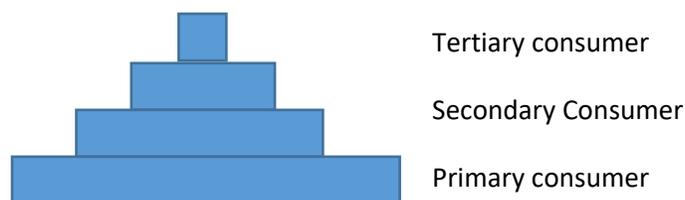


## Ecological pyramids

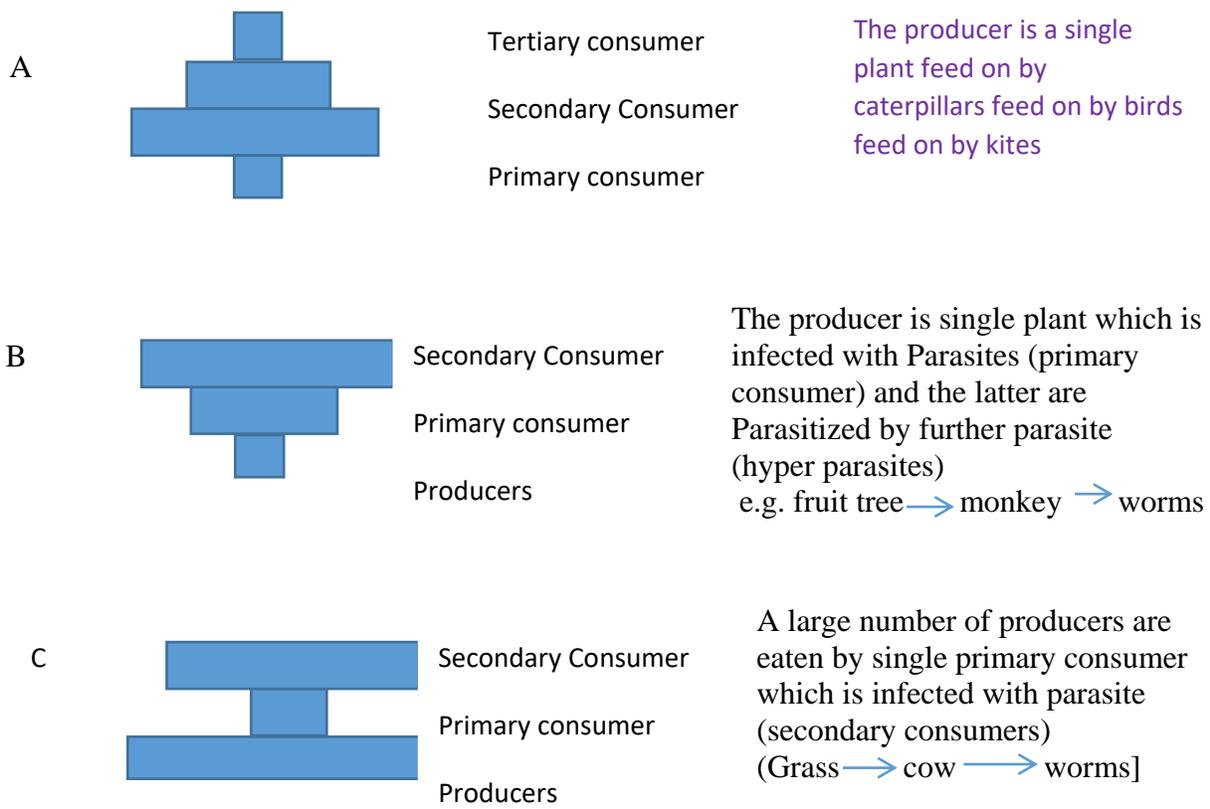
An ecological pyramid is a graphical representation of the trophic structure of an ecosystem, showing the relationships between organisms at different levels of a food chain.

### Pyramids of number

These are pyramid drawn based on the number of organism in each tropical level. Each horizontal bar represents the total number of organisms at that trophic level.



However, pyramid of numbers, despite their name, need not always be pyramidal in shape. Consider the situation where a single very large producer, such as tree, supports a large number of primary consumers. In this case an inverted pyramid of numbers result. Inverted pyramids of numbers can also result when a community contain parasites. Imagine for instance, a mammal infected with tick or fleas. These parasites are in a trophic level above the mammal, yet their numbers will be greater. Some of inverted pyramids of numbers are shown below.



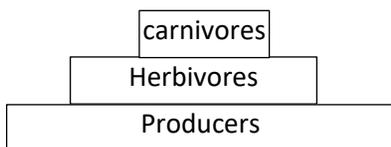
### Pyramids of biomass

This a type of ecological pyramid base not on numbers but biomass. Here instead of counting the number of individual at each trophic level. The total mass (biomass) of organisms at each level is measured. The rectangles used in constructing the pyramid then represent the masses of organisms at each trophic level per unit area or volume. The greatest mass is usually found with the producers, but measurement of the biomass at the various trophic levels in the community may also give an inverted pyramid. For instance, at certain times of year, the biomass of the tiny herbivorous organisms that float in lake and oceans (zooplankton) may exceed the biomass of the tinny photosynthetic organisms (phytoplankton) on which they feed. This is because biomass refers to the mass of organism present a particular moment, the so-called standing crop. **At this time of the year phytoplankton are able to support the zooplankton due to high rate of turnover than that of zooplankton.**

### Pyramid of energy

This is the most fundamental and ideal way of represent relationship between organisms in different trophic levels. A pyramid of energy shows the transfer or flow of energy through a community. As a result, pyramids energy are expressed in units of energy per area per time e.g., kilojoules  $m^{-2}yr^{-1}$ . A generalized pyramid of energy is shown below.

## Pyramid of energy



Consequently, the number of trophic levels in a food chain or the length of the food chain is limited by the energy wasted as it is transferred from organism, i.e. by the efficiency of energy transfer between trophic levels

### Productivity and biomass of ecosystem

- (i) **Biomass** is the total mass of all organic matter in an ecosystem at a given time.
- (ii) **Productivity** is the rate of new biomass generation (e.g., grams per square meter per day). It is classified as

- Gross **primary production** is the total organic material made by photosynthesis in a specified time s known as the.
- Net **productivity** is amount of organic material produced by synthetic organisms actually available to the herbivores since part of gross primary production is respired or decomposed transferred to herbivore or carried downstream.

$$\text{i.e., Net primary productivity} = \left\{ \begin{array}{l} \text{Gross primary} \\ \text{productivity} \end{array} \right\} - \left\{ \begin{array}{l} \text{respired organic matter+ organic matter} \\ \text{decomposed} \end{array} \right\}$$

The percentage of the energy at one trophic level which ends up in the next trophic level is called the **trophic efficiency, usually not more than 10%**. The trophic efficiency of the herbivores, for instance, equals the percentage of the net primary production that is converted to the herbivore production [i.e. to growth and reproduction of herbivores

Lindeman in 1942 proposed that succession involved increase productivity until a climax community was reached in which the maximum efficiency of energy conversion occurred.

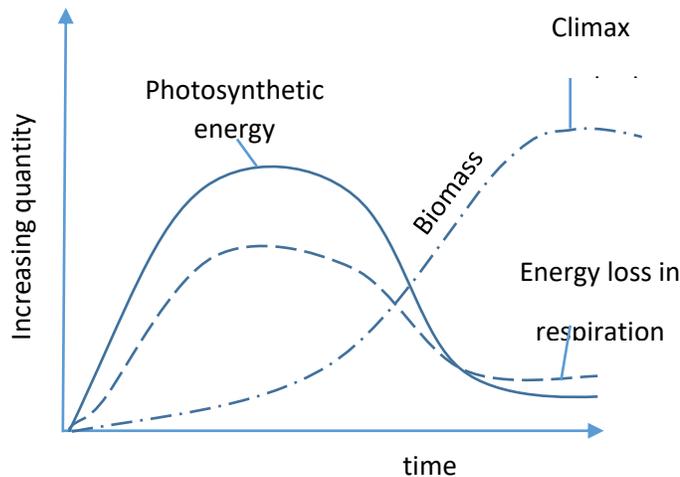
Evidence shows that the latter stages of succession do not become productive, but that there is usually a decline in the gross productivity associated with the climax community. This older forest which in turn may have lower productivity than young forest, which in turn have lower productivity than the more species- rich herb area.

Reason for decrease in production can only be speculated upon but using a forest as an example, older trees might be expected to be less productive than younger trees for several reasons. One is that the accumulation of nutrients in the increasing standing crop biomass may lead to a reduction in nutrient recycling. However, a simple reduction in vigor as the average

age of the individuals in the community increases to a constant point would presumably cause a reduction in productivity.

Succession also leads to maximum accumulation of biomass. This is most obvious in the case of forest community, where the plants become larger and larger during succession, but the accumulated biomass of other climax communities is also normally greater than in the successional stages. Changes in gross productivity, respiration and biomass during a typical succession and summarized on the graph below.

Changes in gross productivity, respiration and biomass during a typical succession



This shows that in a climax community, these terms become more or less constant. It also shows that an upper limit of biomass is reached when total respiratory losses [R] from the system almost equal gross primary productivity [P], i.e.  $P/R = 1$

During a succession more and more of the available nutrients become locked up in the biomass of the community with a consequent decrease in nutrients in the abiotic component of the ecosystem [such as soil and water] the amount of detritus produced increases and detritus feeders take over from grazers as the main primary consumers. Appropriate changes in food webs occur and detritus becomes the main source of nutrients

### Factors Influencing Productivity and Biomass

#### Abiotic Factors:

- **Sunlight:** Higher intensity (e.g., in tropical regions) increases productivity.
- **Temperature:** Warm temperatures generally promote higher productivity.

- **Water:** Availability of moisture and rainfall is crucial.
- **Nutrients:** Essential elements like nitrogen and phosphorus boost biomass production.

#### **Biotic Factors:**

- **Species Interactions:** Competition, predation, and mutualism alter productivity and biomass.
- **Evolutionary Processes:** Can change organism growth and reproduction rates over time.

#### **Examples and Implications**

- **Tropical Rainforests:** High sunlight and rainfall lead to high productivity and biomass.
- **Arctic/Alpine Regions:** Less sunlight and cold temperatures result in low productivity.
- **Ecosystem Health:** Understanding productivity is vital for assessing how well an ecosystem functions and supports life.
- **The 10% Rule:** Only about 10% of the energy from one trophic level is stored as biomass and passed to the next, illustrating why biomass and productivity decrease up the food chain.

### **Effect of human activities on energy flow**

Human activities disrupt the natural flow of energy in ecosystems, leading to cascading effects that can destabilize food webs, reduce biodiversity, and weaken the resilience of ecosystems. Humans interfere at multiple points in the energy transfer process, from the base of the food web to the top, altering the availability and movement of energy.

#### **Altered primary production**

Humans interfere with the foundational energy source of many ecosystems: the conversion of solar energy into biomass by producers.

- (i) **Land-use change:** Converting forests, wetlands, and grasslands for agriculture and urbanization reduces the total amount of photosynthesizing plant biomass. This decreases the overall net primary production (NPP)—the energy available to consumers—and changes the types of plants available.

- (ii) **Acid rain and smog:** Air pollution, primarily from the burning of fossil fuels, releases sulfur dioxide and nitrogen oxides. These pollutants contribute to acid rain, which lowers soil pH and harms plant health. This can reduce photosynthesis rates and, consequently, primary productivity.
- (iii) **Eutrophication:** Excessive nutrient runoff from farms and urban areas causes algal blooms in aquatic systems. While this initially appears to increase primary production, the process ultimately depletes oxygen when the algae die and decompose. This creates "dead zones" where most aquatic life cannot survive, disrupting the base of the food web and altering energy flow.

### Disrupted energy transfer

Human activities can interrupt the energy pathways that connect different trophic levels.

- (iv) **Overharvesting:** The removal of species at any trophic level can have ripple effects throughout the food web. For instance, overfishing of large predatory fish or commercially valuable crustaceans can alter marine trophic chains and biomass flows. When top predators are removed, their prey populations can explode, leading to the overconsumption of organisms at lower levels.
- (v) **Trophic cascades:** A disruption at one trophic level can cause cascading effects. For example, overfishing sharks (apex predators) can lead to an increase in rays, which then devastate the populations of their smaller prey like scallops, affecting humans who rely on that shellfish.
- (vi) **Invasive species:** The introduction of non-native species can alter food webs and energy flow by outcompeting native species for resources or preying on them. Invasive plants, for instance, may not be palatable to native herbivores, forcing energy into a different pathway and potentially leading to a decline in native animal populations.

### Accumulation of toxic energy

Persistent, fat-soluble pollutants from industrial and agricultural activities don't break down easily and build up in living tissue.

- (vii) **Biomagnification:** As these toxins move up the food chain, they become increasingly concentrated. Apex predators, including humans, accumulate the highest levels of these contaminants.
- (viii) **Health consequences:** This buildup can cause severe health effects for top consumers, including reproductive problems, immune suppression, and neurological damage. The

DDT crisis, for example, famously caused eggshell thinning in birds of prey like eagles, leading to population decline.

### Climate change impacts

The burning of fossil fuels releases greenhouse gases that drive climate change, which in turn alters energy dynamics.

- (ix) **Phenological mismatch:** Changes in temperature can cause a mismatch between the timing of a consumer's peak demand and the availability of its food source. For example, if climate change causes caterpillars to hatch earlier, and birds that feed on them do not adjust their egg-laying to match, the birds' young may starve.
- (x) **Reduced transfer efficiency:** In marine ecosystems, ocean warming can shift the composition of primary producers toward unpalatable species like cyanobacteria. This can reduce energy flow from producers to herbivores, causing a collapse in biomass at higher trophic levels.
- (xi) **Ecosystem collapse:** The combined effects of warming and other stressors can weaken food webs, erode biodiversity, and in some cases, lead to the collapse of entire ecosystems.

### Pesticides

Pests are organisms which people consider a nuisance or harmful. Pesticide are substances that kill pests.

Qualities of good pest cide

- It must remain for a short time in the environment i.e. easily transform to a non- toxic form
- It must kill the designated population only or should be specific.
- Should be cheap
- Should be readily available
- Not toxic to people

### Challenges of using pesticide

- a. Non-biodegradable pesticides accumulate in plants and animals causing death
- b. Indiscriminately kill organisms including useful ones including useful ones such as pollinators
- c. Prolonged use may lead to resurgence of resistant strains of pest.

## Bio-accumulation and biomagnification

**Bioaccumulation** is the buildup of substances, such as pesticides or heavy metals, within an organism's tissues over time. This happens when an organism takes in a substance faster than it can get rid of it, resulting in higher concentrations inside the organism than in its surroundings. This is particularly concerning with persistent, fat-soluble toxins, which are stored in fatty tissues and are hard to eliminate. Examples include mercury in fish, DDT in birds of prey, which caused thin eggshells, and PCBs in marine mammals, leading to reproductive and immune problems.

**Biomagnification** is the increasing concentration of toxins *at each level of a food chain*. For example, a large fish eating many small contaminated fish will have a much higher concentration of mercury due to biomagnification.

### Effects of bio-accumulation and bio-magnification on energy flow

Bioaccumulation and biomagnification severely disrupt the flow of energy in an ecosystem by reducing its efficiency at every trophic level. The transfer of toxic substances alongside energy causes physiological harm to organisms, decreases biodiversity, and destabilizes food webs.

### Significance of bioaccumulation and bio-magnification to the health of organisms and the environment in an ecosystem

#### For individuals at lower trophic levels

- (i) **Chronic toxicity:** Even at low environmental concentrations, bioaccumulation means an organism continuously takes in a substance faster than it can excrete it. Over its lifetime, this can lead to toxic levels of the chemical in its body, causing illness and reducing its ability to survive and reproduce.
- (ii) **Physiological impairment:** Bioaccumulated toxins can disrupt normal cellular function, enzyme activity, and metabolic processes. For example, heavy metals can cause oxidative stress and damage internal organs like the liver and kidneys, while some POPs can interfere with hormone systems.

#### For individuals at higher trophic levels

- (iii) **Highest exposure:** Biomagnification means that organisms at the top of the food chain, such as apex predators, accumulate the highest concentrations of toxins. These organisms

consume a large number of prey over their lifespan, and with each meal, they absorb the cumulative toxin load from all the lower trophic levels.

- (iv) **Severe health consequences:** The high concentration of toxins in top predators can cause serious health issues, including neurological damage, reproductive failure, immune system suppression, cancer, and developmental problems. A classic example is the near-extinction of bald eagles due to DDT-induced eggshell thinning.
- (v) **Transgenerational effects:** Toxins stored in fatty tissues, such as PCBs, can be passed from mothers to their offspring during placental development and through breastfeeding, impacting the health of the next generation.

### Ecological imbalance

- (vi) **Population decline and local extinction:** The severe effects of biomagnification on top predators can cause their populations to decline dramatically or even lead to local extinctions. This loss can destabilize food webs, as apex predators often play a crucial role in controlling prey populations and maintaining ecological balance.
- (vii) **Trophic cascades:** The removal or reduction of a predator population due to biomagnification can trigger a trophic cascade. For example, if a predator population declines, its prey might become overpopulated, leading to the overconsumption of organisms at lower trophic levels and causing widespread disruption.
- (viii) **Biodiversity loss:** When species are disproportionately affected by toxins, it can lead to a shift in species composition and a reduction in the overall biodiversity and resilience of the ecosystem.

### Long-term environmental contamination

- (ix) **Persistent pollution:** Many of the substances that bioaccumulate and biomagnify, such as PCBs and heavy metals, are persistent organic pollutants (POPs) that resist environmental breakdown. They can remain in the environment for decades or even centuries, posing a continuous, long-term threat to ecosystems.
- (x) **Resilience and recovery:** Ecosystems contaminated with bioaccumulative and biomagnifying toxins require decades or longer to recover, even after the source of pollution has been removed. Some ecosystems may never fully return to their pre-contaminated state.
- (xi) **Global reach:** The threat is not confined to the source of pollution. POPs can be transported long distances by air and water currents, contaminating remote regions like

the Arctic and Antarctic, which act as "sinks" for global pollutants. This affects wildlife and Indigenous populations that rely on traditional food sources.

## Feed conversion ratio

The feed conversion ratio (FCR) is a measure of an animal's efficiency in converting feed mass into the desired output, such as body mass, milk, or eggs. It is calculated by dividing the total mass of feed consumed by the mass of the output produced over a specific period. A lower FCR indicates greater efficiency, meaning less feed is required to produce the same amount of product.

The formula for FCR is:

$$\text{FCR} = \text{Mass of feed input} / \text{Mass of output} .$$

For animals raised for meat, the "mass of output" is typically the weight gained. For dairy cows, it is the milk produced, and for laying hens, it is the mass of the eggs.

### Factors influencing FCR

An animal's FCR is influenced by a range of factors that affect its metabolism, health, and environment:

- **Genetics and breed:** Some animal breeds are naturally more efficient at converting feed to product due to selective breeding for traits like faster growth rates and leaner muscle mass.
- **Age of the animal:** Younger, growing animals tend to have a lower FCR because they put more energy into growth. As animals age, more of their energy is used for maintenance, resulting in a higher FCR.
- **Feed quality:** The nutritional content of the feed is critical. High-quality feed with the right balance of nutrients leads to lower FCRs. Poor-quality feed forces the animal to consume more to meet its needs, increasing the FCR.
- **Farm management:** Proper management, including biosecurity measures, regular health checks, and maintaining a clean environment, minimizes disease and stress, which can negatively impact an animal's health and FCR.

- **Environmental conditions:** Extreme temperatures, poor ventilation, or overcrowding can stress animals, causing them to divert energy from growth to maintaining body temperature or coping with discomfort. This increases the FCR.
- **Stress:** Animals that are sick, stressed, or live in noisy, poorly managed conditions use more energy for survival rather than for growth, leading to a higher FCR.

### FCR for different livestock

The FCR varies significantly depending on the animal species and production system.

- **Farmed fish and crickets:** Are often the most efficient, with FCRs of 1.0–2.4. Fish are cold-blooded and buoyant, requiring less energy for movement and temperature regulation.
- **Poultry (chickens):** Modern broiler chickens have FCRs of around 1.5–2.0 due to genetic selection and optimized feeding.
- **Pigs:** Typically have FCRs ranging from 2.7 to 5.0.
- **Cattle:** Ruminants like beef cattle are less efficient, with FCRs often in the range of 6.0–10.0 or higher.

### Applications of feed conversion ratio in agriculture

#### 1. Economic and Cost Management:

- **Profitability:** Lower FCR directly reduces feed costs, a major expense, significantly increasing profit margins.
- **Budgeting:** FCR helps farmers accurately forecast feed costs for entire production cycles, enabling better financial planning.

#### 2. Performance Monitoring & Management:

- **Growth Rates:** A lower FCR indicates faster growth and efficient weight gain, helping animals reach market weight quicker.
- **Animal Health:** Good FCR often correlates with good health, fewer illnesses, and reduced need for medication.
- **Feed Quality Assessment:** If animals don't gain expected weight for a given feed amount, it suggests poor feed quality.

### 3. **Operational Decision-Making:**

- **Feed Formulation:** Farmers can choose feed types and ingredients that yield the best FCR.
- **Feeding Strategies:** It guides adjustments to feeding schedules and amounts to prevent overfeeding and waste.
- **Animal Selection:** FCR data helps in selecting breeds or individual animals that are more feed-efficient.

### 4. **Sustainability & Resource Use:**

- **Resource Efficiency:** Better FCR means less feed is consumed, reducing the demand for agricultural land, water, and other resources.
- **Environmental Footprint:** Lower feed requirements decrease waste and lower greenhouse gas emissions associated with feed production.

### 5. **Benchmarking & Industry Standards:**

- **Performance Comparison:** FCR allows farmers to compare their operation's efficiency against industry averages or competitors.
- **Identifying Improvement Areas:** Benchmarking helps pinpoint where management practices, feed, or **animal** health can be improved.

## **Carbon footprint**

A carbon footprint is the total amount of greenhouse gases, like carbon dioxide and methane, emitted directly or indirectly by an entity – for example, a person, product or business.

It is one measure of the impact their activities are having on the environment, and how much they are contributing to climate change.

### **Sources of a carbon footprint**

- **Energy consumption** contributes to carbon footprint because production of thermal electricity uses fossil fuel that release greenhouse gases
- **Transportation** through exhaust fumes from burning fuel
- **Food** contributes to carbon footprints through land use changes like deforestation, on-farm emissions from livestock (methane from burping) and synthetic fertilizers (nitrous

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oxide), processing, transportation, packaging, and waste, with animal products, especially beef.

- **Wastes** contribute to carbon footprint through Emissions from organic waste and the breakdown of products in landfills.
- **Manufacturing** contributes to the carbon footprint primarily through **burning fossil fuels for energy** to power factories, **extraction and processing of raw materials**, **transportation** of goods, and **waste generation**.

### How is a carbon footprint measured?

Measuring a carbon footprint involves assessing the total amount of greenhouse gas emissions produced by an individual or business, and it's typically expressed in terms of carbon dioxide equivalent (CO<sub>2</sub>e).

### How to reduce your carbon footprint

- **Transportation:** Use public transport, cycle, or carpool when possible to reduce emission from fossil fuel. Consider electric or fuel-efficient vehicles.
- **Switch to renewable energy:** Consider switching to renewable energy sources such as solar or wind power.
- **Diet:** Reduce your consumption of red meat and other animal products. Choose more plant-based meals instead.
- **Consumption:** Buy products that are built to last, buy secondhand, and choose sustainably sourced items. Reduce, reuse, and recycle to minimize waste.
- **Improve Efficiency:** Using less electricity through energy-efficient appliances and practices directly lowers demand and, consequently, emissions.
- **Refuse, reduce, reuse, recycle:** Reject single-use plastics, recycle what you can, and donate or sell items when you're done with them.
- **Reduce waste:** Encourage employees to minimise paper use, invest in digital technologies, and choose suppliers that use minimal packaging.

- **Power down:** Use energy-efficient appliances and light bulbs, turn off lights and electronics when not in use, and unplug chargers!

## Carbon sequestration

**Carbon sequestration** is the process of capturing and storing atmospheric carbon dioxide (CO<sub>2</sub>) to reduce its concentration in the atmosphere.

### Types of Carbon Sequestration

- (i) **Natural/Biological:** Using natural systems like forests, soils, and oceans to absorb and store carbon. Photosynthesis in plants and trees, algae etc. convert carbon dioxide into glucose for growth, and store the carbon in their tissues (roots, trunk, leaves). When plants and organic matter decompose, much of the carbon is stored in the soil, remaining there for extended periods.
- (ii) **Artificial/Technological:** Human-initiated processes, such as CCS, that capture and store CO<sub>2</sub> from industrial sources or directly from the air. For instance, Geological methods, involves capturing CO<sub>2</sub> from industrial sources and storing it deep underground in rock formations.

### Importance carbon sequestration

- **Combats Climate Change:** By reducing atmospheric CO<sub>2</sub>, a potent greenhouse gas, carbon sequestration helps slow the rate of global warming.
- **Achieves Climate Goals:** It's a vital approach for achieving net-zero emission targets and stabilizing the global climate.
- **Works with Nature & Technology:** It leverages both natural processes and human-engineered solutions to manage atmospheric carbon.

## Invasive species

An invasive species is a non-native plant, animal, or microbe that can cause harm to its new environment, including damaging the economy, ecosystems, and human health. These organisms often outcompete native species for resources, and because they typically lack natural predators in their new habitat, they can rapidly multiply and become dominant. After habitat loss, invasive species are considered one of the biggest threats to global biodiversity.

## Impact of invasive species

Invasive species in Uganda significantly harm **biodiversity, agriculture, tourism, and human health** by outcompeting natives, degrading habitats, reducing crop yields, blocking waterways, and spreading diseases, as seen with **Water Hyacinth** choking Lake Victoria, and pests like **fall armyworm** devastating staple crops.

### Environmental & Ecological Impacts

- (i) **Habitat Degradation and Loss:** Invasive plants take over native vegetation, diminishing habitat for wildlife. **Example:** In Bwindi Impenetrable National Park, *Lantana camara* forms dense thickets, blocking access to natural food sources for mountain gorillas and forcing them into farmlands.
- (ii) **Biodiversity loss:** Invasive species outcompete native plants and animals for resources, leading to a decline in indigenous species and altering the structure of ecosystems. In Lake Victoria, the introduced Nile perch decimated over 300 native cichlid fish species.
- (iii) **Disruption of Ecosystems:** They compete for resources like water and light, disrupt food chains, and can prevent native plants from growing. **Example, Water Hyacinth** on Lake Victoria crowds out native plants, reducing oxygen and killing fish, impacting the entire aquatic ecosystem. **Secondarily, Nile perch (*Lates niloticus*):** Introduced to Lake Victoria in the 1950s to boost fishing; as a voracious predator, it drove hundreds of native cichlid fish species to near extinction and fundamentally altered the lake's ecosystem.
- (iv) **Spread of Diseases:** Some invasive species can introduce new diseases to native flora and fauna. Mosquitoes and snails that transmit malaria and bilharzia, respectively, often thrive in these environments,

### Agricultural Impacts

- (v) **Reduced Crop Yields:** Pests can decimate crops, leading to significant economic losses for farmers. **Example,** the **fall armyworm** severely threatens staple crops like maize and rice, a critical issue for smallholder farmers in Uganda and across Eastern Africa.
- (vi) **Increased Labor and Costs:** Weeds require extensive manual removal, increasing farmers' labor and production costs. Women in Africa spend billions of hours weeding invasive plants, diverting time from other income-generating activities.

### Economic & Livelihood Impacts

- (vii) **Threat to Tourism:** Invasive species diminish the natural beauty and accessibility of key tourist sites. **Example,** *Water Hyacinth* obstructs boat navigation on lakes, spoiling

experiences like birdwatching and scenic cruises, which are vital for Uganda's tourism industry.

- (viii) **Food Insecurity:** Crop losses due to invasive pests directly threaten food security and can raise food prices, making staples unaffordable. Example, *Parthenium hysterophorus* (**Famine weed**) an aggressive weed has spread across agricultural and grazing lands and directly reduces crop yields and contaminates pastures, affecting food security and livestock health.
- (ix) **Contaminated water:** Dense mats of water hyacinth can make water dirty and green, rendering it unsuitable for drinking and other domestic uses for communities dependent on the lake.
- (x) **Increased poverty:** For communities dependent on natural resources like fisheries and agriculture, the loss of income and livelihoods due to invasive species can exacerbate poverty.

### Health Impacts

- (xi) **Human Health Issues:** Certain invasive plants cause direct health problems in humans. Example, *Parthenium hysterophorus* (Congress Grass) can cause respiratory issues and dermatitis.
- (xii) **Habitat for Vectors:** Floating mats of invasive plants like *Water Hyacinth* can provide breeding grounds for disease vectors.

### Human-Wildlife Conflict

- (xiii) **Crop Raiding:** When invasive plants reduce food availability in parks, gorillas are forced to seek food in nearby communities, leading to increased conflict with farmers.

## Strategies to manage and control the invasive species

Strategies to manage invasive species include

- (i) **Prevention:** Never release exotic pets, aquarium plants, or non-native fish/bait into the wild unless after thorough studies
- (ii) **early detection and rapid response:** Swiftly remove small, new infestations before they become established and much harder to control
- (iii) Use control methods like **mechanical removal**, **chemical application**, and **biological control**,

## Biological control, qualities, examples, advantages and disadvantages

Biological control is a pest management method that uses natural enemies like predators, parasites, and pathogens to suppress populations of pests, weeds, or diseases.

### Examples of biological control agents

- **Predators:** Organisms that hunt and kill pests, such as ladybugs that eat aphids or lacewings that prey on mealybugs.
- **Parasitoids:** Organisms that lay their eggs in or on a host pest, and the larvae consume the host as they develop, such as certain types of wasps.
- **Pathogens:** Disease-causing microorganisms, including fungi, bacteria, and viruses that infect and kill pests.

### Qualities of good biological control agent

- (i) **Host Specificity:** The agent should target only the pest species, minimizing harm to non-target organisms and beneficial insects.
- (ii) **High Reproductive Rate:** The ability to produce many offspring quickly allows the agent to build populations large enough to control pests.
- (iii) **Efficient Searching:** The agent must effectively find hosts or prey, even when pest populations are sparse.
- (iv) **Synchrony with Host:** The agent's life cycle should align with the pest's, ensuring its presence when the pest is most vulnerable.
- (v) **Adaptability:** The agent must be able to survive and function within the local climatic conditions (temperature, humidity).
- (vi) **Survival at Low Densities:** The agent should persist and continue to control pests even when the pest population is low, preventing its own starvation.
- (vii) **High Parasitism/Predation Rate:** The agent should be effective at killing or consuming its target pest.
- (viii) **Rapid Numerical Response:** The agent's population should increase quickly in response to rising pest densities.
- (ix) **Ability to be Mass-Rearing:** For practical applications, the agent needs to be easily and affordably produced in large numbers.
- (x) **Long-Term Control:** The agent should establish a self-perpetuating population that provides ongoing pest suppression.

### Advantages of biological control agent

- Environmentally sound and cost-effective
- Reduces the need for conventional pesticides

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- Once established, it can be self-sustaining
- Often targets specific pests, minimizing harm to beneficial insects

#### **Disadvantage of biological control agent**

- Can be more costly upfront than pesticides
- Results are often slower and less dramatic than with pesticides
- Requires more intensive management, planning, and understanding of pest biology
- Introduction of new species carries the risk of becoming invasive if not carefully managed

## **Food security**

Food security is when all people, at all times, have physical and economic access to enough safe and nutritious food that meets their dietary needs and preferences for an active, healthy life. It is built on four pillars: physical availability of food, economic and physical access to food, utilization (nutrition and sanitation), and stability (consistent access over time). Food insecurity occurs when these conditions are not met, and can be chronic or acute.

#### **Four pillars of food security**

- **Availability:** This refers to the physical supply of food through domestic production, imports, or aid.
- **Access:** Individuals must have the economic and physical ability to acquire food. This includes having enough resources to buy or grow food.
- **Utilization:** This dimension ensures that food is used properly. It involves having adequate nutrition, clean water, sanitation, and access to healthcare to meet physiological needs
- **Stability:** A household or population must have consistent access to food at all times. This means not being vulnerable to sudden shocks (like an economic crisis) or cyclical events (like seasonal food shortages).

#### **Causes and consequences of food insecurity**

- **Causes:** Food insecurity can be caused by poverty, high food price inflation, and economic or climatic crises. Other factors include inadequate care practices, poor health services, and unhealthy environments.
- **Consequences:** The result is food insecurity, which can lead to malnutrition, stunted growth in children, and poor health outcomes.

## Addressing food security

- **Strategies** for addressing food security often involve a combination of economic growth and direct interventions.
- This includes income growth, investments in health, water, and education, and efforts to reduce food loss and waste.

## Sustainable agricultural practices to address food insecurity

Sustainable agricultural practices address food insecurity by **enhancing crop yields, improving soil health, conserving water, boosting climate resilience, and supporting local food systems** through methods like crop rotation, agroforestry, conservation agriculture, organic farming, and climate-smart agriculture. These practices not only increase productivity but also make farming systems more resilient to environmental changes, empower farmers, and improve nutrition for communities.

### Key Sustainable Practices

- **Crop Rotation:** Alternating different crops in the same field to maintain soil fertility, break pest and disease cycles, and reduce the need for synthetic inputs.
- **Agroforestry:** Integrating trees with crops and/or livestock to increase yields, improve soil health, conserve water, and provide additional income.
- **Conservation Agriculture:** Practices like minimum tillage, cover cropping, and crop rotation that reduce soil erosion, enhance soil health, and improve water retention.
- **Organic Farming:** Using natural fertilizers and biological pest management to improve soil quality and fertility, leading to increased food production over time.
- **Climate-Smart Agriculture (CSA):** A comprehensive approach that aims to sustainably increase productivity, adapt to climate change, and reduce greenhouse gas emissions.

## How They Address Food Insecurity

- **Increased Productivity:** Practices like improved seed varieties, intercropping, and organic farming boost crop yields and farmer incomes.
- **Environmental Stewardship:** They protect natural resources by improving soil health, conserving water, and reducing pollution from synthetic chemicals.
- **Climate Resilience:** They help farmers adapt to climate change through methods like drought-resistant crops and rainwater harvesting.

- **Improved Nutrition:** Promoting crop diversification and community gardens provides access to a wider variety of nutrient-dense local foods.
- **Empowered Communities:** Training programs, farmer cooperatives, and local food hubs strengthen farmers' livelihoods and improve community access to food.

### Supporting Elements

- **Capacity Building:** Training and workshops to teach farmers new techniques.
- **Policy Advocacy:** Engaging with policymakers to create supportive agricultural policies.
- **Community Initiatives:** Establishing community gardens and farmers' markets to promote local food production and access.
- **Seed Banks:** Preserving local crop varieties to ensure biodiversity and access to quality seeds.

## Pollution and conservation

Pollution is the damaging release by humans of materials and energy to environment than can be removed by the environment. The materials or energy released are called pollutants.

The pollutants may be biodegradable or non-biodegradable. Biodegradable pollutants like sewage are broken down by micro-organism to harmless substances fairly quickly, whereas non-biodegradable pollutants cannot be so readily broken down. They tend to accumulate and are therefore potentially more dangerous. Below are specific examples

### Pollution due to carbon dioxide accumulation

Accumulation of carbon dioxide (from burning fossil fuel, deforestation, etc.) contributes to the global warming or greenhouse effect. The greenhouse is a slow progressive increase in the average temperature of the earth over a time.

The effects of global warming

- Melting of ice on mountain tops and earth pole leading to floods
- Droughts in subtropical latitude (5-350N)

### Means of reducing carbon dioxide concentration in air

- Using alternative source of energy other than fossil fuel such as solar electricity or nuclear energy
- More energy-saving measures could be introduced.
- Massive tree planting programs to lock up carbon dioxide in the wood
- Nutrient enrichment of the oceans might allow huge algal blooms which would trap carbon dioxide in organic matter.

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## Oil pollution

Oil pollution results in spillage from the petroleum carrying ship. When inevitable accidents happen or when oil refineries are bombed during the time of war. Oil being lighter than water, floats on sea, killing birds and other animals it may also prevent photosynthesis by blocking carbon dioxide.

### Methods of treating oil pollution include

- a. Setting fire on the oil
- b. Pumping the oil back into special oil collecting ship
- c. Adding naturally occurring bacteria that can digest oil
- d. Adding special spill cleaners that are relatively nontoxic and biodegradable than previously used detergents.

## Pollution due to damage to ozone layer

Ozone,  $O_3$ , is found at low concentration in the earth's stratosphere, 15 to 50km up. Here it protects the earth from dangerous radiations that out damage the cell genetic material leading to cancers. Ozone layer may be damaged by chlorofluorocarbons (CFCs) used as coolant in refrigerators

## Pollution due to Pesticides

Pests are organisms which people consider a nuisance or harmful.  
Pesticide are substances that kill pest.

Challenges of using pesticide

- d. Non-biodegradable pesticides accumulate in plants and animals causing death
- e. Indiscriminately kill organisms including useful ones including useful ones
- f. Prolonged use may lead to resurgence of resistant strains of pest.

## Acid rain

Acid rain is due to releases of acidic gases such as sulphur dioxide ( $SO_2$ ) and nitrogen dioxide ( $NO_2$ ) usually from unregulated industries. Low pH of acid rain is damaging to organism tissues. It causes skin corrosion, and contributes to destruction of forests in Europe and Northern America.

## Pollution due to sewage

Sewage is the water-borne waste of society.

It includes both domestic and industrial sewage.

Domestic sewage contain human feces and urine, water used to wash these away and dirty water flows from our baths and sinks.

Industrial sewage includes the dirty water from industry, hospital and abattoirs. Agricultural sewage is not allowed to mix with domestic and industrial waste and is treated separately.

If untreated sewage or agricultural fertilizers are allowed to enter lakes or rivers, eutrophication may occur. Eutrophication is enrichment of water with nutrients such as nitrogen and phosphorus. This leads to overgrowth of algae (or algal bloom) which use up oxygen in water leading to death of fish. Death of fish lead to over multiplication of aerobic decomposers, cause further depletion of water and death of fish.

### **Pollution due to radiations**

Radiations from radioactive substance lead to death and oor injury of people and animal by causing cancers.

### **Conservation**

This involves managing the earth so as to restore and maintain a balance between the requirements of human and those of other species.

There are two main reasons why we should conserve.

- a. The ethical reason is that we have a moral duty to look after the environment.
- b. The pragmatic argument says that it is to our advantage to ensure the integrity of our environment. If we preserve the tropical rain forest, the greenhouse effect will be lessened; if we conserve fish stock, we get more food from seas, etc.

Revision exercise

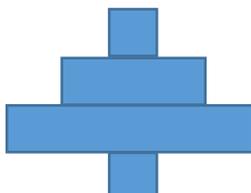
Objective type questions

1. The number of trophic levels in a food chain is mainly determined by the A  
Deficiency of energy transfer between levels  
Biomass of the producer  
Net productivity of ecosystem  
Species diversity of the ecosystem
2. Which one of the following characteristics of a parasite is not a means of ensuring A  
continuity of species of the parasite?  
Degeneration of redundant body structures  
Protection against host enzymes  
Means of penetrating other organisms  
Means of dispersing offspring
3. The biomass of consumer is always less than that of producers because C  
Producers have to support consumers  
Consumers have a low productive rate  
Energy is lost through body process of consumer  
Consumers are small in size
4. In estimating the population of tilapia in a fish pond, 60 fish were captured, marked A  
and released. After 2 days, 50 were captured and out of which 10 were marked. The  
population of tilapia in the pond was  
300  
400  
200  
100
5. A good pesticide is one which D  
Kills a wide range of organism  
Persist for a long time after its application  
Kills pests at different trophic levels  
Easily transforms to non-toxic forms
6. Which one of the following is not used to describe a population of organism? B  
Density  
Biodiversity  
Size  
distribution
7. Mosses growing on the bark of a tree form an association with the tree is called C  
mutualism  
parasitism  
commensalism  
predator
8. Which one of the following equation shows the correct relationship between gross, D  
primary productivity (GPP) and net productivity (NPP) in plants?  
 $GPP = NPP + \text{photosynthesis}$

NPP = GPP – photosynthesis  
GPP = NPP – plant respiration  
NPP = GPP – plant respiration

9. Which one of the following activities does not contribute to the greenhouse effect? B  
Deforestation  
Afforestation  
Burning of fossil fuel  
Emission of gases from industries
10. Which one of the following is correct about organism in an ecosystem? A  
Some organisms exist in isolation  
Every organism can be independent  
Each organism has a different source of food  
All organism interacts with each other
11. Which one of the following methods of estimating population has the highest chances of error? C  
Removal method  
Quadrat method  
Capture-recapture method  
Direct count method

- 12 The figure shows a pyramid of numbers for a food chain C



Tertiary consumer  
Secondary Consumer  
Primary consumer

The most likely mode of nutrition relationship between producer and primary consumers is

- Mutualistic  
Symbiotic  
Parasitic  
autotrophic
13. Which one of the following environmental factors has direct effect on all organisms? C  
Light  
Humidity  
Temperature  
Rainfall  
Temperature affects enzymes
14. Which one of the following factors reduces interspecific competition in a A

- community?  
 Resource partitioning  
 High intraspecific competition  
 Large number of species  
 Similar producer-prey strategies among the species.
15. Which one of the following is **not** exhibited by well adapted parasite? C  
 Inflicting moderate harm to its host  
 Employing an intermediate host  
 Killing the host  
 Using more than one host
16. Depletion of the ozone layer is caused by D  
 Greenhouse effect  
 Release of carbon dioxide in the atmosphere  
 Penetration of ultraviolet light  
 Release of the chlorofluorocarbon in atmosphere
17. The type of succession where recolonization of an area results into a different C  
 community from the original one is known as  
 Primary  
 Dominant  
 Deflected  
 secondary
18. Radioactive rays are particularly dangerous in nature because they C  
 cannot be absorbed by plant so they only affect animals  
 accumulate in animals and return to the soil animals die  
 cause extremely high temperatures in the environment  
 accumulate in high concentrations at high trophic levels
19. Determining the commonest plant species in a large habitat within a short time can A  
 be best carried out using the  
 line transect  
 quadrat  
 direct count  
 aerial view  
 A line transect involves the use of tape or sting running along ground in a straight line between two designated points. Sampling is rigorously confined to species actually touching the line. This gives a quick method of identifying the commonest plant species in a large habitat.
20. Excessive use of pesticides in the long term affect mostly A  
 carnivore  
 parasites  
 producers  
 herbivores
21. Which one of the following is true about the environment of a forest floor under a B

thick canopy?

Has wide temperature fluctuations

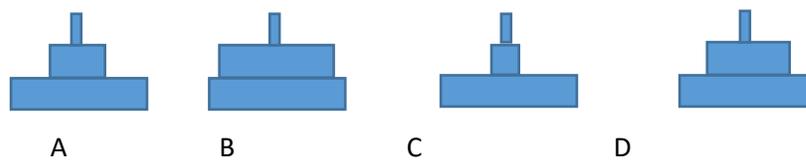
Receives far red light

Develop dense plant growth

Has heavy soil erosion

In the presence of a thick canopy, ordinary light cannot penetrate to reach the plants under the canopy. However, far red light has more energy and can therefore penetrate the canopy, therefore, it is far light that is received and utilized by the plants under the canopy.

22



B

In which pyramid does the primary consumer make efficient use of the producer i.e. it derived the highest percentage of energy from producers

23 Which one of the following factors has the greatest limiting influence on the population of algae at the bottom of a pond? A

Light

Carbon dioxide

Mineral salts

oxygen

24. Which one of the following factors does not affect the distribution and abundance of D organism?

Mimicry

Predation

Human species

speciation

25. Which one of the following would be an effect of decreasing competition on a stable B population?

Increasing the environmental resistance thereby increasing the population

Lowering the environmental resistance thereby increasing the population

Lowering the environmental resistance thereby decreasing the population

Increasing the environmental resistance thereby decreasing the population

26. Algae have much smaller biomass compared to a large producer such as trees but c may have the same productivity because

A lot of material and energy are locked up in the dead xylem tissue of the tree.

The algae have a very high turn-over

Algae have a high rate of reproduction

- The rate of growth and death in algae is high
27. Predators in top trophic levels in food chain are most severely affected by persistent pesticides because
- Their system are highly sensitive to chemicals
  - They have high reproductive rates
  - They cannot store pesticides in their tissues
  - The pesticides become concentrated from their prey
28. Nitrifying bacteria convert ammonia into nitrites and nitrites into nitrates in order to
- Enrich the soil
  - Generate energy for synthesis of organic compounds
  - Maintain the nitrogen cycle
  - Reduce the amount of nitrogen in the atmosphere
29. Three counts of 103, 46 and 20 of plant species, were made using a quadrat of 25cm<sup>2</sup>. The density of plant per m<sup>2</sup> is
- 169
  - 56.3
  - 22,533
  - 22.5
30. Which one of the following ecological pyramid may be used to determine the productivity in an ecosystem?
- Pyramid of energy
  - Pyramid of biomass
  - Pyramid of numbers
  - Pyramid of productivity
31. Which one of the following forms of environmental hazards is attributed to application of CFCs?
- Greenhouse effect
  - Acid rain
  - Ozone layer depletion
  - Eutrophication.
32. Which one of the following processes does not affect the biochemical oxygen demand?
- Ammonification
  - Nitrogen fixation
  - Nitrification
  - Denitrification
33. Which one of the following constitutes the most energy transfer?
- Praying mantis feeding on flies
  - Aphids feeding on plant sap
  - Cat feeding on small mammals
  - Beetle larvae feeding on dung

- i.e. from producer to primary consumer
34. Which one of the following has the greatest biomass in an ecosystem? B  
 Tertiary consumer  
 Primary producer  
 Secondary consumer  
 Primary consumer
35. Which one of the following is not a problem that endoparasite face in their transmission? A  
 Leaving the host  
 Entering the host  
 Living away from the host  
 Identifying the host
36. Which one of the following statement is correct about the exponential phase in the population growth? B  
 Death rate and birth rate are equal  
 Number of individuals and rate of growth increase  
 The number outstrip the supply of factors for support  
 Slow growth of the population
37. The number of organisms in each trophic level reduces as one moves up a food chain A because  
 Energy is lost in moving from one trophic level to another  
 Energy is lost from the top levels  
 Organism in higher trophic levels are less productive  
 Of high level of predation at the top trophic levels
38. Which of the following activities has least contribution to global warming? A  
 Use of pesticide  
 Deforestation  
 Burning fossil fuel  
 Use of CFCs
39. During which energy transfer is most energy lost in an ecosystem? A  
 Producer ~~Primary~~ primary consumer  
 Primary consumer ~~secondary~~ secondary consumer  
 Secondary consumers ~~tertiary~~ tertiary consumer  
 Tertiary consumer ~~decomposer~~ decomposer
40. The bacteria which convert nitrates to nitrites during the nitrogen cycle are example of D  
 Nitrogen fixing bacteria  
 Nitrifying bacteria  
 Decomposing bacteria  
 Denitrifying bacteria
41. A climax community is one in which C

Succession

A carrying capacity has been reached

Succession has ceased

Death rate of organism is at its lowest

42. Good drainage and ploughing of soil reduces the process of C
- Nitrification  
Decomposition  
Denitrification  
Nitrogen fixation  
i.e. aerates the soil
43. In any ecosystem, a continued input of energy is required because D
- Matter is continually used in metabolism  
Biological succession occurs very slowly  
Of the continued increase in population in ecosystem  
Energy is lost each time it is transferred between organisms
44. Which of the following would contribute to greenhouse effect B
- Use of nuclear power  
Use of fossil fuels  
Excessive use of fertilizers  
Accumulation of sewage in water bodies
45. In the energy transfer in an ecosystem, the greatest loss in energy is between A
- Primary producer and primary consumer  
Primary consumers and secondary consumers  
Secondary consumer and tertiary consumer  
Tertiary consumers and decomposers
46. From a bush, 120 beetles were collected and, marked and released back into the C  
bush. A few days later 120 beetles were collected from the same place, and 30 of  
them carried the mark. The estimated number of beetles in the bush is
- 240  
360  
480  
560
47. Energy flow in an ecosystem refers to the energy D
- Consumed in total, by all organisms

Consumed by the organism at each energy level  
Converted from light to chemical energy by the primary producer  
Transferred from the primary producer through the various consumers.

48. Which one of the following parasites is unicellular? B  
Taenia  
Plasmodium  
Ascaris  
trypanosome
49. Which of the following ecological effects may not be caused by deforestation? C  
Species extinction  
Reduction in soil fertility  
Acid rain  
Flooding and land slides
50. Which of the following characteristics of a parasite would increase its chance of survival? C  
Being highly specific  
Inflicting severe effects on host  
Parasitizing more than one type of host  
Employing no vector
51. Which one of the following would be a characteristic of a poorly adapted parasite? D  
Employing vectors  
Inflicting mild harm to the host  
Having a dormant stage during the life cycle  
Inflicting severe harm to the host
52. Which of the following methods of controlling malaria would cause least damage to the environment? D  
Draining swamps  
Spraying swamps and ponds  
Spraying oil over stagnant water  
Introducing fish into the swamp and ponds
53. The mycorrhiza on some plants serve to  
Fix nitrogen from atmosphere  
Absorb mineral salts from the soil  
**Break down humus**  
Synthesize carbohydrates
54. In which of the following situations would population growth occur? C  
When the number of  
Birth equals the number of deaths  
Birth plus the number of immigrations is less than the number of deaths plus the number of emigration.  
Birth plus the number of immigrations is greater than the number of deaths plus the number of emigration.  
Deaths plus the number of emigration is greater than the number of births plus the

number of immigration.

- 55 Which of the following features are most useful to amphibians in living in aquatic habitat? B  
Moist skin, membrane around eggs, and gills  
Membrane around eggs, gills and webbed feet  
Long hind limbs, short fore limbs and gills  
Webbed feet, moist skin and gills
- 56 Which one of the following is an intracellular parasite? B  
Trypanosome  
Plasmodium  
Schistosome  
Hook worm
- 57 There is a limited biomass at each trophic level in a food chain because at each level, there is B  
Reduction in the number of organisms  
Loss of energy  
Reduction in size of organisms  
Reduction in amount of food.
- 58 How many reproductive stages does malarial parasite undergo to complete the life cycle?  
1  
2  
3  
4
- 59 Which one of the following describes greenhouse effect? C  
Depletion of the ozone layer increases atmospheric temperature.  
The earth retains the heat gained from the sun  
Increasing atmospheric carbon dioxide prevents heat loss from earth surface  
The earth gives out carbon dioxide which prevents light rays from the sun reaching the earth.
- 60 The reproductive stage of plasmodium in the liver is represented by the  
Zygote  
Gametocyte  
Merozoite  
sporozoite

- 61 Plant roots in association with symbiotic bacteria is an indication that the plant is unhealthy  
the roots have been attacked  
soil around roots lacks nitrogen  
soil around roots lack humus c
- 62 Which one of the following is not a component of environmental stress? C  
Lack of light  
Lack of shelter  
Topography  
diseases
- 63 A dodder plant, which attaches on stems of various plants is yellow in appearance. c  
This indicates that the plant  
lacks roots  
lacks certain minerals  
is parasitic  
lacks supporting tissues
- 64 Which one of the following is not a structural component of ecosystem? D  
Green plants  
Decomposers  
Predators  
Solar system
- 65 The existence of ring worm on human skin is an example of A  
Parasitism  
Mutualism  
Commensalism  
symbiosis
- 66 What is meant by ecological niche? d  
Conditions in which the organism lives  
Specific localities with particular set of conditions  
Geographic region, cutting across continents  
Precise place of an organism and what it does there
- 67 Which of the following best describes how pesticides have become dangerous today? C  
The pesticide  
Persist in the soil and make it infertile  
Harden the soil  
Pass through food chains in more concentrated forms  
Cause eutrophication in water and kill fish.
- 68 The competitive exclusion principle attempts to explain why A  
A particular niche contains one species  
Pioneer plants are not found in established community  
There is rarely more than five trophic levels in an ecosystem  
The diversity of a habitat increases as succession proceeds

- 69 Insectivorous plants are most likely to be found growing in B  
 Soil with high organic matter contents  
 Soil with low nitrogen content  
 Soil with low pH  
 Alkaline soil
- 70 A species of beetle recently introduced to control the water hyacinth in Uganda B  
 lakes. If the beetles reduced the spread of the weed, this would be an example of  
 Ecological balance  
 Biological control  
 Dominancy of species  
 Successful competition
- 70 Which of the following is the correct sequence representing the action of nitrifying B  
 bacteria?  
 Nitrites → nitrates → Ammonium salts  
 Ammonium salts → Nitrites → nitrates  
 Nitrites → Ammonium salts → nitrates  
 Ammonium salts → nitrates → Nitrites
- 71 Which one of the following process does not affect the biochemical oxygen demand D  
 in an environment?  
 Nitrification  
 Ammonification  
 Nitrogen fixation  
 Denitrification  
 i.e. denitrification does not require oxygen
- 72 A non-mutualistic role of bacteria in ruminant animals is that they D  
 Secrete enzymes for hydrolysis of carbohydrates  
 Break down food into small fragments to ease enzyme action  
 Produce bacterial proteins which is used by ruminant  
 Are preyed on by the ruminants
- 73 Which of the following is the main reason why insects eggs usually hatch rapidly into C  
 larvae?  
 Eggs have little yolk  
 Hatching is controlled by external factors  
 It is a way of avoiding predators  
 Due to excessive production of juvenile hormone
- 74 Good drainage and ploughing of soil reduces the process of C  
 Nitrification  
 Decomposition  
 Denitrification  
 Nitrogen fixation  
 Because it aerates the soil

- 75 Which of the following is true about a population where there is no environmental resistance? The population A  
 Grows exponentially  
 Inflicts mild pain to the host  
 Having a dormant stage during the life cycle  
 Inflicting severe harm to the host
- 76 Which of the following would does not affect the pH directly?  
 Absorption of bases by plant roots  
 Production of carbon dioxide by plant roots  
 Leaching  
 Water logging
- 77 Plant roots in association with symbiotic bacteria is an indication that C  
 The plant is unhealthy  
 The roots have been attacked  
 Soil around the roots lacks nitrogen  
 Soil around the roots lacks humus
- 78 Which one of the following sequence correctly represents the action of nitrifying bacteria? A  
 Ammonia → nitrites → nitrates  
 Ammonia → nitrate → nitrites  
 Nitrite → nitrate → ammonium  
 Nitrite → ammonium → nitrates
- 79 Which of the methods below is most suitable for estimating the population of paramecium in a pond? C  
 Capture-recapture method  
 Total count  
 Removal method  
 Random sampling
- 80 The introduction into Uganda to species of South American beetles which naturally feed on water hyacinth is an example of: C  
 Herbivory  
 Predatory  
 Biological control  
 Ecological balance
- 81 The data below indicate the concentration, in parts per million, of a pesticide in the bodies of some organisms that in an area after 20years of use of pesticide. A
- |               |         |             |            |
|---------------|---------|-------------|------------|
| Phytoplankton | tilapia | zooplankton | fish eagle |
| 0.04          | 2.07    | 0.23        | 13.80      |

The most probable reason for the fish eagle to have the highest concentration of the pesticide is that  
 The pesticide accumulates in the fatty tissue of fish eagle

Fish eagles are at the end of food chain represented by organisms.  
Fish eagle take more food than other organisms  
The elimination of pesticides is less efficient in fish eagle than in other organisms.

- 82 Radioactive rays are particularly dangerous in nature because they C
- A. cannot be absorbed by plants so they only affect animals.
  - B. accumulate in animals and return to the soil when animals die.
  - C. cause extremely high temperatures in the environment.
  - D. accumulate in high concentrations at high trophic levels.

Radioactive rays often cause extremely high temperatures in the environment by giving up their high energies to materials through which they pass. This is a great disadvantage in nature.

- 83 Depletion of the ozone layer is caused by D
- A. greenhouse effect.
  - B. release of carbon dioxide in the atmosphere.
  - C. penetration of the ultraviolet rays.
  - D. release of the chlorofluorocarbons in atmosphere.

Chlorofluorocarbons (CFCs) are chemical compounds which directly attack and deplete the ozone layer.

### Structured questions

1. What is parasitism? (1mark)  
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State **three physiological** adaptations of endo parasites. (3marks)

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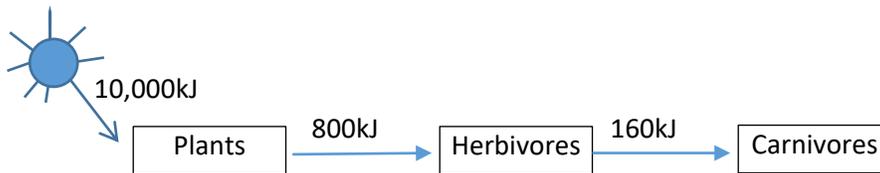
Give **three** advantages of a parasitic mode of life to the parasite (3marks)

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(d) Describe three ways of a parasite-host relationship which ensures the success of a parasite. (3marks)

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2. The figure shows energy flow in a food chain



(Assuming 10% of the energy received by herbivores is lost, calculate the energy retained. (03marks)

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Explain why

Energy transfer from herbivores to carnivores is more efficient than that from producers to herbivores. (3marks)

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The efficiency of energy transfer from herbivores to carnivores is less than 100%. (02marks)

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State the factors which limit the number of trophic levels in a food chain. (02marks)

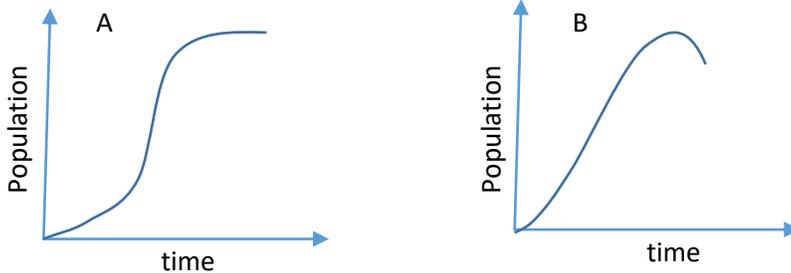
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3. The below show the two forms of population growth curves of animals



Indicate by drawing on curve The carrying capacity of the environment (01mark)

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Compare the pattern of population changes in curve A and curve B (2marks)

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Suggest an explanation for the population changes in curve B. (4marks)

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Suggest three biotic factors which can result into a change in carrying capacity, in an environment. (03marks)

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4. State three ecological problems which arise from accumulation of domestic waste in urban communities (03marks)

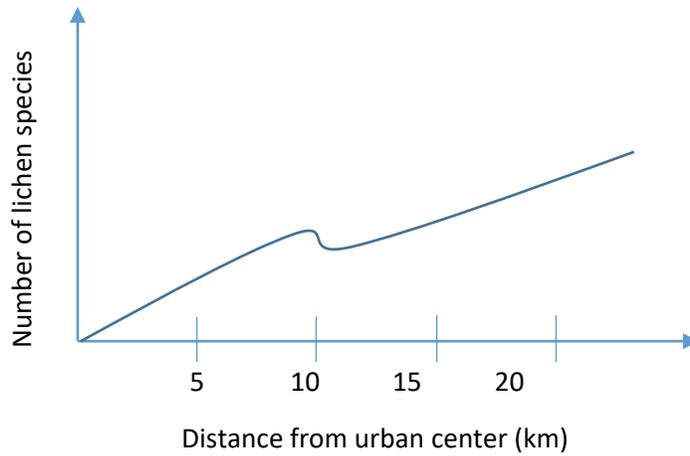
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Give two ways of reducing domestic waste (2marks)

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The figure below shows lichen species growing along a 20Km transect from an urban Centre.



Explain the trend in the lichen species with distance from urban centre (3marks)

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Suggest an explanation for the observed number of lichen species at a distance of 10km from urban center (2marks)

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5. How can predation be beneficial to the prey? (02marks)

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Give factors that may affect the predator prey balance in nature (4marks)

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Outline ways by which humans affected the predator-prey balance resulting into harmful consequences (04marks)

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6. (i) Describe how a quadrat method can be used to determine species density. (2marks)

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state the advantages and disadvantages of the method. (2marks)

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(i) why is it important to estimate population size?

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in estimating the number of fish in a small lake, 625 fish were caught, marked and released. After one week, 920 fish were caught and of these, 150 had been marked. What was the estimated size of fish population (2 marks)

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In using the method in b(ii) estimate the population size of fish, state two assumptions that were made (2marks)

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7 The table shows the amount of DDT measured in parts per million(ppm) Found in a variety of organisms associated with a fresh water lake

Where the DDT level was measured	Amount of DDT/ppm
Water	0.0003
Phytoplankton	0.006
Zooplankton	0.004
Herbivorous fish	0.39
Carnivorous fish	1.8
Fish-eating birds	14.3

(i) Calculate how many times the DDT is more concentrated in carnivorous fish compared with its concentration in water (2marks)

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What does the results show?

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Explain why concentration of DDT changes from water to carnivorous fish. (03marks)

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© State two effect of DDT to organism (02marks)

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Explain how a pest sprayed with a pesticide may flourish afterwards? (3marks)

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8. State two human activities that increase the levels of carbon dioxide in the atmosphere. (2marks)

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What is the effect of high levels of each of the following gases in atmosphere? (7marks)

Carbon dioxide

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Sulphur dioxide

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State one indicator in the environment where there is prevalence of high level of sulphur dioxide in the environment. (1mark)

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9. State the importance of the following elements in plant metabolism  
Calcium (1mark)

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Magnesium (1mark)

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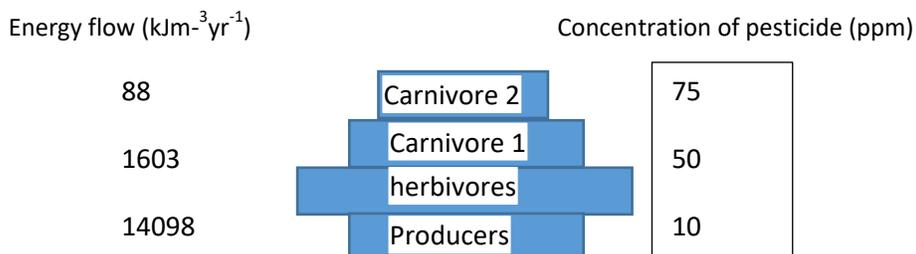
How does water logging of the soil affect its nitrate content? (3marks)

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Describe three special ways of obtaining essential elements by some plants growing in soil deficient on those elements. (5marks)

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- 10 In an aquatic ecosystem which was affected by an insecticide, analysis of energy flow and concentration of the pesticide at each level in a food chain was made. The results are shown on the pyramid of biomass of the ecosystem, in figure below.



What does the width of each bar of the pyramid represent? (1mark)

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Explain why, from producer to secondary consumer, The level of pesticide increase (2marks)

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The flow of energy decrease? (2marks)

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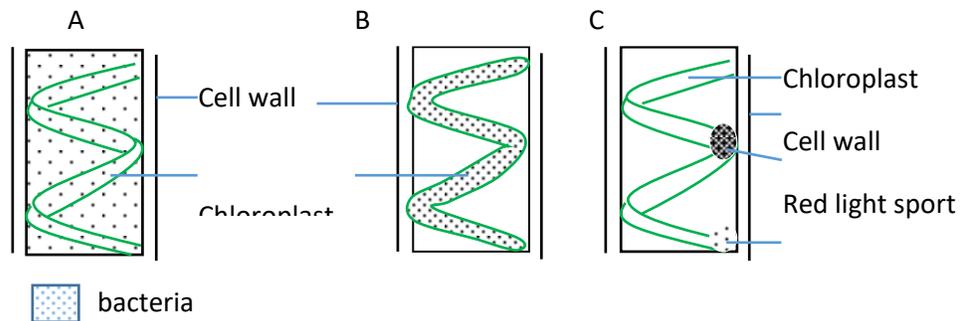
From the biomass, explain how the producer can sustain the herbivores (2marks)

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Give three ecological problems that may arise through the use of pesticides. (3marks)

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11 One strand of spirogyra was placed on each of three microscope slides A, B and C. the spirogyra was in water contained aerobic, free-moving bacteria. The three slides were placed under conditions shown in figure below. After one hour of incubation, the results are shown below.



Describe the distribution of bacteria on the three slides A, B, C. (3marks)

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Explain the distribution of bacteria on each slide (7marks)

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12 The table shows the concentration of organism chloride in different organism inhabiting a pond. Study the table and answer the question that follow.

organism	Planktons	Large fish	Fish eagle	Small fish
Concentration of organic chloride (ppm)	0.04	0.5	25	40

Comment on the data given in table above

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Using the information given in the table, construct a possible food chain in the pond.

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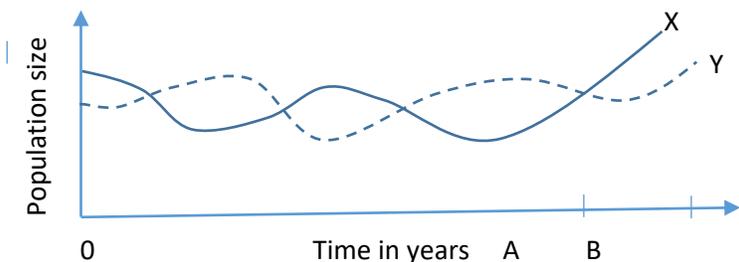
Explain the high concentration of chlorine in the fish eagle

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Suggest the properties you would recommend for a suitable chemical to use in water purification

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13. The figure shows changes in the size of a population of a producer and the consumer in a lake over time.



State which curve represents the  
Producer ..... ( ½ mark)  
Consumer ..... ( ½ mark)

Explain the interaction between the two population before point A (5marks)

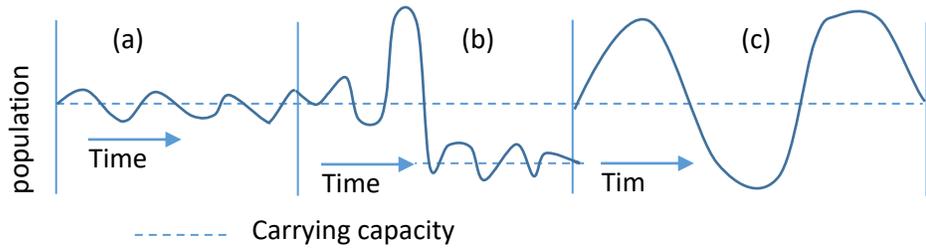
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Suggest how human activities could result in the interactions of the population between points A and B (4marks)

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14 The figure shows population growth curves partten (a), (b) and (c) that occur naturally



Describe and suggest reasons for thr observed pattern of each population growth curve (3marks)

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(4marks)

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(3marks)

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15. What is meant by **eutrophication**? (2marks)

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State two human activities that may encourage eutrophication (2marks)

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What is the effects of eutrophication? (04marka)

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Effects of eutrophication are more sevee in water bodies where thermal polution occurs.  
Explain. (2marks)

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16. What do you understand by **biological control**? (2marks)

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What consideration must be made before application of a biological pest control method?  
(2marks)

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(i) state **two** ways in which chemical pest control method can upset ecosystem(2marks)

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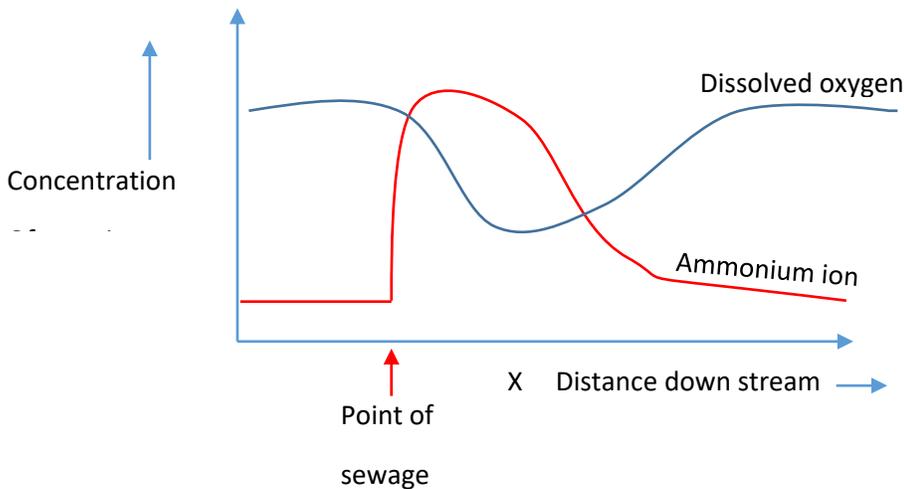
Suggest **two** reasons why pests eventually flourish after a period of pesticide application. (2marks)

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.....

Suggest three characteristics of a good pesticide (3marks)

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17. The graph below shows the effect of sewage discharge on some chemical constituents of a river at increasing distance down stream form the point of sewage discharge



Give explanation for the variation in concentration of ammonium ions and dissolved oxygen, down stream from the point of sewage discharge  
Ammonium ion (3marks)

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ii) dissolved oxygen (3marks)

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Describe the effect of sewage on the ecosystem at distance X down stream.(4marks)

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### Assay questions

1. (a) What is a food chain? (2marks)  
(b) Explain how energy flows through an ecosystem? (08marks)  
(c) How does temperature influence the distribution of organism? (8marks)
3. (a) What is ecological impact of each of the following human activities?
  - (i) Use of pesticide (6marks)
  - (ii) Use of artificial fertilizers (4marks)
  - (iii) Over fishing (5marks)(b) Describe advantages of biological pest control over pesticides in an ecosystem. (5marks)
4. (a) Describe the relationship between organisms in the lichen. (06marks)  
(b) Compare mutualism and parasitism. (7marks)  
(c) Explain how termite are able to feed on wood. (07marks)
5. (a) Explain how ferns are better adapted for terrestrial life than mosses (08marks)  
(b) How does temperature influence the following processes in plant?
  - (i) Plant growth (07marks)
  - (ii) Plant distribution (05mark)
6. (a) Outline the causes of nutrient deficiency in soil (4marks)  
(b) Explain how plants have overcome the problems of nitrogen and phosphorous deficiencies in soils they grow in. (16marks)
7. (a) What is meant by
  - (i) Biotic potential? (3marks)
  - (ii) Primary productivity? (2marks)(b) Discuss the factors which influence the size of the population in ecosystem (12marks)  
(c) Suggest reasons why human populations are not naturally regulated by negative feedback mechanisms (3marks)
8. Figure 1, 2, 3 shows the immigration and extinction of species on different categories of virgin islands.

Figure 1 shows the rate of immigration of new species on a island nearby the shore and one that is far from the shore.

Figure 2 shows the rate of extinction of species on a large island and on small island

Figure 3 shows the rate of immigration and extinction of species on the island.

Study the information and use it to answer the questions that follow.

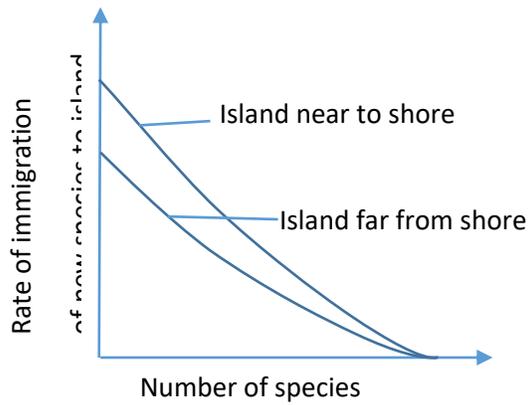


Figure 1

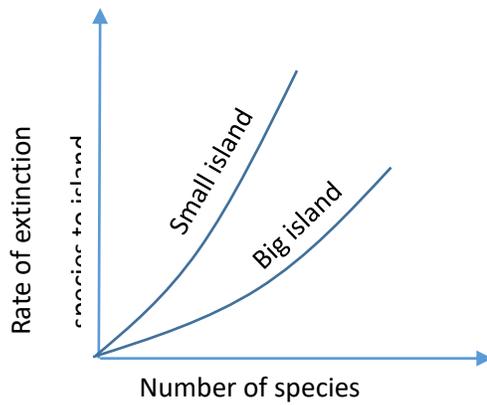


Figure 2

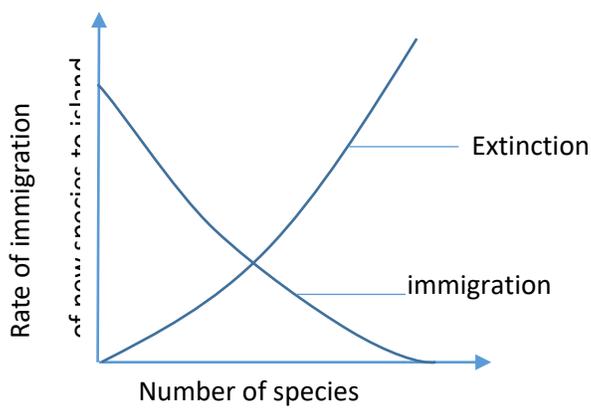


Figure 3

- (a) Explain the rate of
    - (i) Immigration of new species on an island that is near to the shore and one that is far from the shore (figure 1) (10marks)
    - (ii) Extinction of species on a small island and on a large island (figure 2) (09marks)
    - (iii) Immigration and extinction of species on an island (figure 3 (7marks)
  - (b) From figure 1, 2, 3 what conclusions can you draw about what determines the number of species on an island? (05marks)
  - (c) Describe how factors other than those depicted in information provided, may affect the immigration of new species on an island. (4marks)
  - (d) Suggest the factors that would cause immigration of new species to a virgin land. (5marks)
- 9 (a) What is biological pest control (2marks)
- (b) Explain the precautions to be taken in application of biological pest control (06marks)
- (c) Describe the ecological qualities of a good pesticides
- 10 (a) Describe the trend of succession that would take place on a bare rock. (10marks)
- (b) Outline the flow of energy in the climax community described in (a) (10marks)
- 11 Describe the influence of biotic factors, excluding man, on the distribution of organisms in nature. (20marks)
- 12 (a)(i) Describe how plants absorb nitrates from the soil.  
 (ii) Give three ways in which plants use nitrates they have absorbed.
- (c) Describe ecological effects of drainage of nitrate fertilizers into rivers and streams.
- 13 (a)(i) outline the importance of population size of different organisms in a given area to an ecologist  
 (ii) Differentiate between sample count and total count.
- (b) Give five factors to be considered before carrying out counting. exercise
- (c) Describe a suitable method you would use to estimate the population of
- (i) Fish e.g. tilapia
  - (ii) Flying insects in a woodland.
- Give reasons for your choice
- 14 (a) Describe the physiological and structural factors of the water hyacinth which enabled it to spread and persist on Lake Victoria.
- (b) Outline the ecological dangers of this weed on the water
- (c) Suggest three control methods of the water weed, and for each method point out one weakness.
- 15 (a) Explain how plants living under the canopy of forest trees are able to survive (15marks)
- (b) Describe how herbaceous plants are supported of the ground (05marks)

- 16 Graphs A, B and c shows results of three experiments that were carried out to study the relationship between a predator, *Didinium* and a prey Paramecium under three set of conditions.

In the first experiment, Paramecium was introduced into a culture at point **P** and Didinium at point **D** as shown in figure1

In the second experiment, Paramecium and Didinium was introduced to ether at point **P + D** at different population densities. This is shown in graph **B** of figure 1

In the third experiment, Paramecium and Didinium were introduced together at point P +D at different densities. And after every three days as shown by the arrow in the graph in graph C of figure 1.

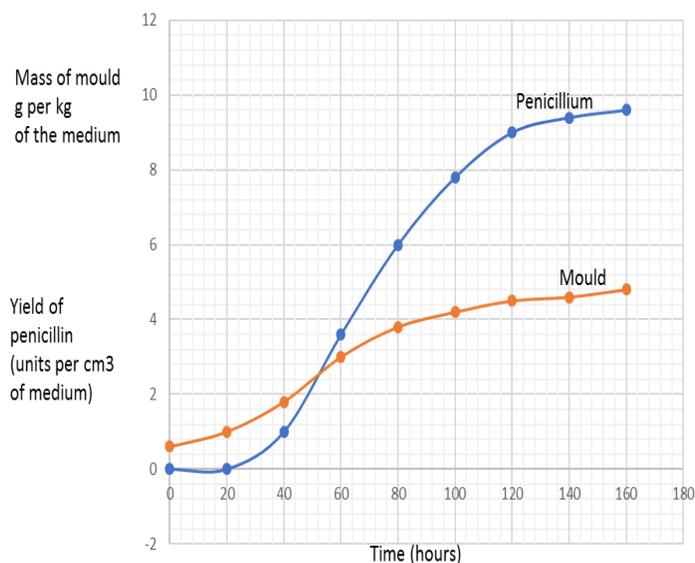
Study the graphs and answer the questions that follow.

- (a) Describe the trend of the population growth of Paramecium and Didinium in graph.
- (i) A (04marks)
- (ii) B (03marks)
- (iii) C (04marks)
- (b) Explain the interaction of the two species of organism in graph
- (i) A (06marks)
- (ii) B (06marks)
- (c) Compare the trend of the population growth of the two species in graph B and C. (05marks)
- (d) Supposing Paramecium and Didinium were introduced at the same time under natural environmental conditions, sketch curves to show the expected trend of population with time (5marks)
- (e) Explain the trend of the population curves of Paramecium you have drawn in (d) (5marks)
- 17 How are vertebrates adapted to terrestrial life (20marks)
- 18 Growth of two microorganisms in culture media and yield of their products was analyzed. The table shows the growth of the yeast and yield of its product ethanol.

Time (hrs)	Mass of yeast (g per dm <sup>-3</sup> of the medium)	Yield of ethanol (g per 100cm of the medium)
0	1.0	0.2
2	1.4	0.4

4	2.4	0.6
6	4.2	1.3
8	5.9	2.5
10	6.2	2.8
12	6.1	2.6
14	5.8	2.2

Graph 1 shows the growth of the ascomycete mould *Penicillium* and the yield of its products penicillin. Use the data to answer the questions that follow



Graph 1

- (a) Represent the information in the table graphically (6marks)  
Use your graph and graph1, to answer question (b) –(f)
- (b) Describe the patterns of growth of the mould and yeast (6marks)
- (c) Give two differences in the growth pattern of the mould and yeast.  
(4marks)
- (d) Explain what is happening in the growth of yeast population during each of the following:  
(i) 0 - 2 hours  
(ii) 4 - 6 hours  
(iii) 8 - 10 hours  
(iv) 12 – 14 hours (8marks)
- (e) Describe the relationship between the

- (i) Growth of mould and yield of penicillin
  - (ii) Growth of yeast and production of ethanol (4marks)
  
  - (f) State three ways in which the pattern of accumulation of penicillin in graph 1 differs from the pattern of accumulation of ethanol on your graph. (6marks)
  
  - (g) Ethanol is a direct product of metabolic process essential for the life of the organism. Penicillin is a product of metabolic process which is not essential to keep the organism alive.  
Suggest how the differences in the pattern of accumulation of these two products may be related to their differing roles in the metabolism of the producer organisms. (2marks)
  
  - (h) State the economic importance of saccharomyces and penicillium (4marks)
- 18 The distribution of the stomata and other leaf modification in plants are indicative of their habitats. Discuss. (20marks)

Thank you Dr. Bbosa Science