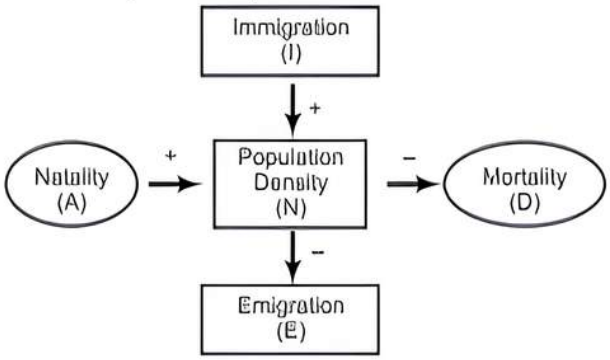
11 Organisms and Populations

Fastrack Revision

- **Ecology** is the study of the interactions among organisms and between the organism and its physical (abiotic) environment.
- Ecology deals with four levels of biological organisation:
  - **Organism:** A living entity which can function on its own.
  - **Populations:** Sum of all living organisms of the same species living in a particular geographical area.
  - **Communities:** A group of people living together in one place.
  - **Biomes:** A large geographical area of various plants and animals.
- **Population:** A group of individuals living in a geographical area who can interbreed and share or compete for similar resources is called a **population.**
- **Population Attributes**
  - A population has certain attributes such as **birth rates** and **death rates** and in a population, these rates refer to per capita births and deaths respectively.
  - The rates are expressed as increase or decrease in number of the members of the population.

  Examples:
  - If in a pond, there are 20 lotus plants last year and through reproduction 8 new plants are added, taking the current population to 28, the birth rate is calculated as 8/20 = 0.4 offspring per lotus per year.
  - If 4 individuals in a laboratory population of 40 fruit flies died in a week, the death rate in the population during that period is 4/40 = 0.1 individuals per fruit fly per week.
  - Another attribute characteristic of a population is **sex ratio.**
  - An individual is either a male or a female but a population has a sex ratio.
  - A population at any given time is composed of individuals of different ages.
  - If the age distribution is plotted for the population, the resulting structure is called an **age pyramid.**
  - The shape of the pyramids reflects the growth status of the population whether it is growing or stable or declining.
  - Population size is more technically called **population density,** designated as N.
  - Population density can be measured by:
    - Counting the number
    - Percent cover
    - Pug marks and fecal pellets for tiger census
- **Population Growth**
  - The size of a population keeps changing in time, depending on various factors including food availability, predation pressure and reduced weather.
  - The density of a population in a given habitat during a given period, fluctuates due to changes in four basic processes which are:
    - **Natality** refers to the number of births during a given period in the population that are added to the initial density.
    - **Mortality** is the number of deaths in the population during a given period.
    - **Immigration** is the number of individuals of the same species that have come into the habitat from elsewhere during the time period under consideration.
    - **Emigration** is the number of individuals of the population who left the habitat and gone elsewhere during the time period under consideration.



If N is the population density at time t, then its density at time $t+1$ is:

$N_{t+1} = N_t + [(B + I) - (D + E)]$, where

B = Number of births

I = Number of immigrants

D = Number of deaths

E = Number of emigrants

N = Population density

t = Time period

- **Growth Models**

  There are two models used to measure the growth of population:

  I. Exponential Growth
  - When resources in the habitat are unlimited, each species grow in number and reach enormous population density in a short time.
  - If in a population of size N, the per capita birth rates and per capita death rates are represented as b and d respectively, then the increase or decrease in N during a unit time period t will be dN/dt.

$\therefore$ $dN/dt = (b - d) \times N$

Let $(b - d) = r$, then

$dN/dt = rN$

The 'r' in this equation is called the **'intrinsic rate of natural increase'.**

- The above equation describes the exponential or geometric growth pattern of a population and results in a J-shaped curve when we plot N in relation to time t.
- The integral form of the exponential growth equation is

$N_t = N_0 e^{rt}$,

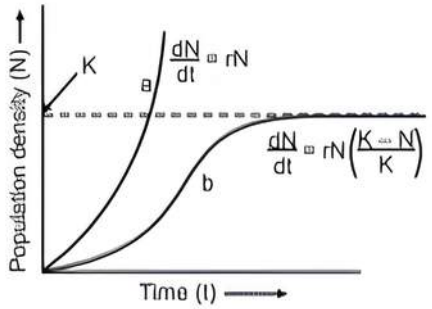
where,

N_t = Population density after time t

N_0 = Population density at time zero

r = Intrinsic rate of natural increase

e = The base of natural logarithms (2.71828).



II. Logistic Growth

- When the resources in the habitat are finite, it limits the growth of the species.
- A population growing in a habitat with limited resources show initially a lag phase, followed by phases of acceleration and deceleration and finally an asymptote, when the population density reaches the carrying capacity.
- This type of population growth is called **Verhulst-Pearl Logistic Growth** and is described by the following equation:

$dN/dt = rN[(K-N)/K]$

where, N = Population density at time t

r = Intrinsic rate of natural increase

K = Carrying capacity.

▸ Life History Variations

- Populations evolve to maximise their reproductive fitness called as Darwinian fitness (high or value) in the habitat in which they live.
- Organisms evolve towards the most efficient reproductive strategy under a particular set of selection pressures.
- According to ecologists, life history traits of organisms have evolved in relation to the constraints imposed by the abiotic and biotic components of the habitat in which they live.

▸ Population Interactions

- Interspecific interactions arise from the interaction of populations of two different species.
- Interspecific interactions could be beneficial, detrimental or neutral to one of the species or both.
- Both the species benefit in **mutualism** and both lose in **competition** in their interactions with each other.
- In both **parasitism** and **predation,** only one species benefits.
- The interaction where one species is benefitted and the other is neither benefitted nor harmed is called **commensalism.**
- In **amensalism,** one species is harmed whereas the other is unaffected.
- Predation, parasitism and commensalism share a common characteristic *i.e.*, the interacting species live closely together.
- The different types of population interactions are described as:

I. Predation

- It is an interspecific interaction where organisms of higher trophic levels feed on organisms of lower trophic level.
- Herbivores are predators as they feed on grass.
- Exotic species have no predators, hence they grow very rapidly. **Example:** The prickly pear cactus introduced into Australia and the invasive cactus was brought under control only after a cactus-feeding moth was introduced in the country.

Importance of Predation in an Ecosystem

- Predator keeps prey populations under control.
- Predator acts as a passage for transfer of energy across trophic levels.
- Predators help in maintaining species diversity in a community by reducing the intensity of competition among competing prey species.
- Some species of insects and frogs are cryptically-coloured (camouflaged) to avoid being detected easily by the predator.
- Some are poisonous and therefore avoided by the predators.
- The Monarch butterfly is highly distasteful to its predator (bird) because of a special chemical present in its body which is acquired by feeding a poisonous weed during caterpillar stage.
- All insects are known to be phytophagous as these feed on plant sap and other parts of plants.
- Thorns in *Acacia* and cactus are morphological means of defense against insects.
- Many plants produce and store some chemicals which make the herbivores sick if eaten and even kill the predators.
- Calotropis produces poisonous cardiac glycosides against herbivores.
- Nicotine, caffeine, quinine, opium are produced by plant as defenses against the grazers and browsers.

II. Competition

- Competition is struggling by the organisms for the same resources like food, shelter and sex.
- The competition between two organisms belonging to same species is called **Intraspecific competition.**
- The competition between organisms belonging to different species is called **Interspecific competition. Example:** In some shallow South American lakes, visiting flamingoes and resident fishes compete for their common food, the zooplankton in the lake.
- Resources need not be limiting for competition to occur. **Example:** Abingdon tortoise in Galapagos Islands became extinct within a decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.

- The occurrence of competition in nature comes from competitive release.
- **Competitive release** is the process in which a species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range dramatically when the competing species is experimentally removed.
- Connell's elegant field experiments showed that on the rocky sea coasts of Scotland, the larger and competitively superior barnacle *Balanus* dominates the intertidal area and excludes the smaller barnacle *Chathamalus* from that zone.
- Gause's **'Competitive Exclusion Principle'** states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated eventually.
- Species facing competition might evolve mechanisms like resource partitioning that promotes co-existence rather than exclusion.
- If two species compete for the same resource, they could avoid competition by choosing different times for feeding or different foraging patterns, this is called **resource partitioning.**
- MacArthur showed that five closely related species of warblers living on the same tree were able to avoid competition and co-exist due to behavioural differences in their foraging activities.

III. Parasitism

- Parasitism is the association between two organisms in which one organism is benefitted and another organism is harmed.
- Some of the parasitic adaptations are:
  - Loss of unnecessary sense organs
  - Presence of adhesive organs or suckers to cling on to the host
  - Loss of digestive system
  - High reproductive capacity.
- The life cycles of parasites are often complex, involving one or two intermediate hosts or vectors to facilitate parasitisation of its primary host.
- The human liver fluke, which is a trematode parasite, depends on two intermediate hosts, a snail and a fish to complete its life cycle.

Effects of Parasites on the Host

- Majority of the parasites harm the host.
- They may reduce the survival, growth and reproduction of the host and reduce its population density.
- They might render the host more vulnerable to predation by making it physically weak.
- Parasites that feed on the external surface of the host organism are called **ectoparasites.**

Examples:

- The lice on humans and ticks on dogs.
- *Cuscuta*, a parasitic plant that is commonly found growing on hedge plants, has lost its chlorophyll and leaves in the course of evolution and derives its nutrition from the host plant which it parasitises.

- Many marine fish are infested with ectoparasitic copepods.
- **Endoparasites** are those that live inside the host body at different sites. **Examples:** Tape worm, liver fluke.
- **Brood parasitism** is the process in which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them.
- The eggs of the parasitic bird are similar with the egg of the host. **Example:** Cuckoo lays eggs in the nest of the crow.

IV. Commensalism

- The type of interaction in which one species benefits and the other is neither harmed nor benefitted is called commensalism.

Examples:

- An orchid growing as an epiphyte on a mango branch.
- Barnacles growing on the back of a whale.
- Clown fishes living among stinging tentacles of sea anemone.

V. Mutualism

- Mutualism is the interaction between two living organisms where both the organisms are equally benefitted and no one is harmed.

Examples:

- Lichens represent an intimate mutualistic relationship between a fungus and photosynthetic algae or cyanobacteria.
- *Mycorrhizae* are associations between fungi and the roots of higher plants, where the fungi help the plant in the absorption of essential nutrients from the soil while the plant, in turn, provides the fungi with energy-yielding carbohydrates.

- Plants provide nectar and pollen for pollinating agents and the pollinating agents in turn pollinate the flowers of plants.
- Animals disperse the seeds of plants and plants provide juicy fruits for seed dispersers.
- Fig tree is pollinated by a species of wasp only where the wasp pollinates the fig inflorescence while searching for suitable egg-laying sites. In return for the favour of pollination, the fig offers the wasp some of its developing seeds as food for the developing wasp larvae.

VI. Amensalism

- The interaction in which one species is harmed while the other is neither benefitted nor harmed is called amensalism.

  Example: *Penicillium* inhibits the growth of various bacteria by secreting penicillin.

▶ **Sexual Deceit**

- Sexual deceit is the process in which petal of its flower bears an uncanny resemblance to the female of the bee in size, colour and markings. **Example:** the Mediterranean orchid *Ophrys*.
- The male bee is attracted to what it perceives as a female, 'pseudocopulates' with the flower, and during that process is dusted with pollen from the flower.
- When the same bee 'pseudocopulates' with another flower, it transfers pollen to it and thus, pollinates the flower.

Practice Exercise

Multiple Choice Questions

Q 1. Basic unit of ecological hierarchy is:
a. population b. community
c. ecosystem d. individual

Q 2. Several plant and animal species present together at a place constitute a:
a. genus b. population
c. biome d. community

Q 3. The branch of science which studies the interactions among organisms and between organisms and physical environment is called as:
a. epidemiology b. ecology
c. ethology d. etiology

Q 4. Ecotone is:
a. a polluted area.
b. the bottom of a lake.
c. a zone of transition between two communities.
d. a zone of developing community.

Q 5. Autocology is the:
a. relation of heterogenous population to its environment.
b. relation of an individual to its environment.
c. relation of a community to its environment.
d. relation of a biome to its environment.

Q 6. Which of the following would necessarily decrease the density of a population in a given habitat?
a. Natality > mortality
b. Immigration > emigration
c. Mortality and emigration
d. Natality and immigration

Q 7. A protozoan reproduces by binary fission. What will be the number of protozoans in its population after six generations?
a. 128 b. 24 c. 64 d. 32

Q 8. At a particular locus, the frequency of allele A is 0.8 and that of allele a is 0.2. What would be the frequency of heterozygotes in a random mating population at equilibrium? *(CBSE SQP 2023-24)*
a. 0.32 b. 0.16 c. 0.24 d. 0.48

Q 9. Lichens are the associations of:
a. bacteria and fungus b. algae and bacterium
c. fungus and algae d. fungus and virus

Q 10. A tight one-to-one relationship between many species of fig tree and certain wasps is an example of: *(CBSE 2023)*
a. commensalism b. parasitism
c. amensalism d. mutualism

Q 11. Important attributes belonging to a population but not to an individual are: *(CBSE 2023)*
(i) Birth rate and death rate
(ii) Male and female
(iii) Birth and death
(iv) Sex-ratio
Select the correct option from the given options:
a. (I) only b. (II) only
c. (ii) and (iii) d. (i) and (iv)

Q 12. If the age distribution is plotted for a population, the resulting structure is called as:
a. age graph b. age curve
c. age pyramid d. age diagram

Q 13. Which of the following factors influence population density under normal conditions?
a. Deaths b. Immigration
c. Emigration d. Both a. and c.

Q 14. Exponential growth is observed in a population when:
a. resources in the habitat are unlimited.
b. each species has the ability to realise its full innate potential.
c. Both a. and b.
d. None of the above

Q 15. Which of the following equations correctly represents the exponential population growth curve?
a. $dN/dt = rN$ b. $dN/dt = rN(1-N/K)$
c. $Nt = N_0e^{rt}$ d. Both a. and c.

Q 16. The population growth is generally described by the following equation:

$$dN/dt = rN(1-N/K)$$

What does *r* represent in the given equation?
a. Population density at time 't'.
b. Intrinsic rate of natural increase.
c. Carrying capacity.
d. The base of natural logarithm.

Q 17. Two different species can not live for long duration in the same niche or habitat. This law is called:
a. Allen's law
b. Gloger rule
c. Competitive exclusion principle
d. Weismann's theory

Q 18. The interdependent evolution of flowering plants and pollinating insects together is known as:
a. mutualism b. co-evolution
c. commensalism d. co-operation

Q 19. Interaction between clown fish living among the stinging tentacles of sea anemone is an example of: *(CBSE 2023)*
a. Amensalism b. Parasitism
c. Mutualism d. Commensalism

Q 20. Many copepods live on the body surface of marine fish. This relationship is an example of: *(CBSE 2023)*

a. Commensalism b. Parasitism
c. Amensalism d. Mutualism

Q 21. Identify the option that does not exhibit a parasitic relationship:

a. Head lice in humans
b. *Cuscuta* on a mango tree
c. Female *Anopheles*
d. Ticks on dogs

Assertion & Reason Type Questions

Directions (Q. Nos. 22-27): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes a, b, c and d as given below.*

a. Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c. Assertion is true but Reason is false.
d. Assertion is false but Reason is true.

Q 22. Assertion (A): Emigration is outward movement of some individuals from local population.
Reason (R): Emigration is caused by occurrence of deficiencies and calamities.

Q 23. Assertion (A): Many plants growing in oligotrophic soils possess mycorrhizae.
Reason (R): Mycorrhizae help in efficient absorption of nutrients.

Q 24. Assertion (A): Mycorrhizal relation exists between Boletus and *Pinus*.
Reason (R): It is a symbiotic interaction.

Q 25. Assertion (A): Predation and parasitism are considered to be negative interactions.
Reason (R): Predators and parasites limit the population of their host species.

Q 26. Assertion (A): Generally the intraspecific competition is more intense than interspecific competition.
Reason (R): Intraspecific competition occurs when the resources are in short supply.

Q 27. Assertion (A): Amensalism is a negative interaction between two living individuals.
Reason (R): In amensalism, allochemics are secreted by one individual.

Answers

1. (d) Individual
An organism (or an individual) is a living unit of nature and is the most basic unit of ecological hierarchy.
2. (d) community
Biotin community is an assemblage of populations of different species of plants, animals, bacteria and fungal which live in a particular area and interact with one another through competition predation, mutualism, etc. Each biotin community has a specific composition and structure, *e.g.*, pond community.
3. (b) ecology
4. (c) a zone of transition between two communities
5. (b) relation of an individual to its environment.
6. (c) Mortality and emigration
7. (c) 64
By binary fission, an individual protozoan will divide into two. In this way, after six generations their member will be 64.

1st division	—	1-2
2nd division	—	2-4
3rd division	—	4-8
4th division	—	8-16
5th division	—	16-32
6th division	—	32-64

8. (a) 0.32
9. (c) fungus and algae
10. (d) mutualism
11. (d) (i) and (iv)
12. (c) age pyramid
Age distribution is percentage of individuals of a given age group. A population at any given time is composed of individuals of different ages. If age distribution is plotted for the population, the resulting structure is called as age pyramid.
13. (a) Deaths
Under normal condition births and deaths influence density of a population the other two factors being only active under special condition.
14. (c) Both a. and b.
15. (d) Both a. and c.
16. (b) Intrinsic rate of natural increase.
17. (c) Competitive exclusion principle
18. (b) co-evolution
The evolution of complementary adaptations in two species caused by the selection pressures that each exerts on the other is called co-evolution. It is common is symbiotic associations, *e.g.*, many insect-pollinated plants have evolved flowers whose shapes, colours, *etc.*, make them attractive to particular insects, at the same time the pollinating insects have evolved sense organs and mouth parts specialised for quickly locating and extracting nector from particular species of plants.

19. (c) Mutualism
20. (b) Parasitism
21. (c) Female *Anopheles*
22. (b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
23. (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
24. (b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
25. (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
Predation and parasitism are negative interactions as predator destroys the prey and parasites rob their host's nutrition, causes injury leading to reduction in reproduction.
26. (b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
27. (b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

Case Study Based Questions

Case Study 1

Habitats of Organisms

Organism P has thick lips and tongue so that it can easily feed on the commonly available spiny plants. Organism Q has thick layer of insulating fat under the skin. It was strong hooves to walk steadily on steep surfaces and lives in burrows during winters. Organism R has bright colours and sticky pads on its fingers and toes. It lives on trees.

Q 1. Which of the following is correct habitat for organism P regarding its adaptation?
a. Grassland biome
b. Desert biome
c. Tropical rainforest
d. Tropical deciduous forest

Q 2. Which of the following is correct match regarding organism Q and its habitat?
a. Tundra - Polar bear
b. Tropical rain forest - Deer
c. Grassland - Bighorn sheep
d. Desert - Camel

Q 3. Which of the following is incorrect regarding organism R's habitat?
a. The vegetation shows stratification.
b. Epiphytic growth is rich.
c. Standing crop is highest.
d. Deep rooted shrubs are common due to abundant sunlight.

Q 4. The dominant plants in habitat where P lives could be:
a. *Opuntia* b. *Nymphaea*
c. *Deodar* d. Both a. and c.

Answers

1. (b) 2. (a) 3. (d) 4. (a)

Case Study 2

Population Interaction

During teaching about various environmental factors, a teacher draws a figure that depicts like history strategies for three plant species (X, Y and Z) along 3 axes - strength of competition with other organisms, level of disturbance in the habitat and level of environmental stress in the habitat. Species X grows in habitats where competition among species is high, but disturbance and stress are low. Species Y grows in habitats with high environmental stress but with low intraspecies competition. Species Z grows in highly disturbed habitats with low environmental stress.

Q 1. Which of the following is correct regarding plant type X?
a. It has slow growth rate.
b. It lives in area with high probability of severe environmental changes.
c. It has good competitive ability at low population densities near the carrying capacity.
d. None of the above.

Q 2. Environmental stress occurs through:
a. very low temperature b. drought
c. nutrient deficiency d. All of these

Q 3. Select the correct option regarding plant type X, Y and Z.
a. X type of plants is likely to be trees
b. Y type of plants could be desert plants
c. Z type of plants could be herbaceous plant
d. All of the above

Q 4. Y type of plants grow under high stress and:
a. produce large number of seeds in a short time after rains
b. have rapid growth
c. Both a. and b.
d. produce less number of seeds in a long time after rain

Q 5. Assertion (A): Plant growth rate is high in areas of high stress and high disturbance.
Reason (R): High stress and high disturbance promote breeding capacity in plants.
a. Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
c. Assertion is true, but Reason is false.
d. Both Assertion and Reason are false.

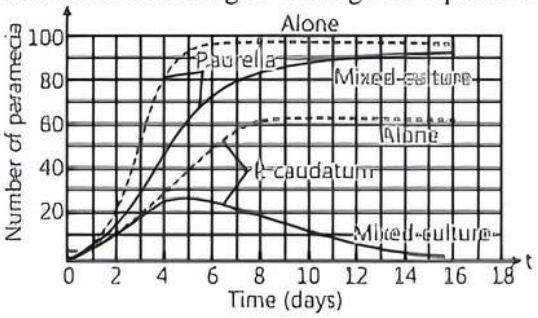
Answers

1. (a) 2. (d) 3. (d) 4. (a) 5. (d)

Case Study 3

Observe the graph given below:

The graph represents inter-specific interaction between two species of Paramecia competing for the same resource in a culture medium. *Paramecium caudatum* and *Paramecium aurelia* were grown in separate cultures as well as in mixed cultures. It was found that each species grew in numbers according to the logistic equation.



Q 1. Which species is competitively superior? Support it with the data provided in the graph.

Ans. *P. aurelia* species is competitively superior. *P. aurelia* grows in numbers more quickly than *P. caudatum* and shows more individuals in the same volume of culture/100 *Paramecium aurelia* in 6 days whereas 60 *P. caudatum* in 8 days.

Q 2. State the underlying principle for the above result and name the scientist associated with this principle.

Ans. Competitive Exclusion Principle is the underlying principle which states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated.

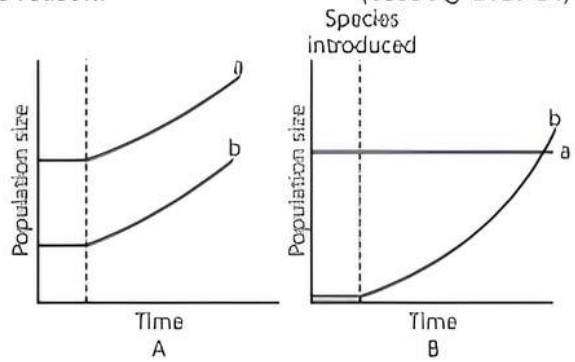
G.F. Gause is the scientist associated with this principle.

Q 3. Explain the mechanism in which two or more species competing with each other can co-exist.

Ans. One such mechanism is 'resource partitioning'. If two species compete for the same resource, they could avoid competition by choosing different times for feeding or different foraging patterns, to avoid competition and co-exist due to behavioural differences in their foraging activities.

OR

Graphs A and B shown below depict interaction of two species. Which graph indicates Mutualism? Give reason. *(CBSE SQP 2023-24)*



Ans. Graph A- As both species grow simultaneously.

Case Study 4

Population Growth

Growth of a population with time shows specific and predictable patterns. two types of growth pattern of population are exponential and logistic growth. When resources in the habitat are unlimited each species has the ability to realise fully its innate potential to grow in number. Then the population grows in exponential fashion. When the resources are limited growth curve shows an initial slow rate and then it accelerates and finally shows giving the growth curve which is sigmoid.

Read the given passage carefully and give the answer of the followings questions:

Q 1. Give the equation which represents the exponential population growth curve.

Ans. If any species is flourishing under unlimited resources, it would reach exponential growth which can be depicted by equation:

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

Where N = population density at time; r = intrinsic rate of natural increase.

If we derive the integral form of the exponential growth equation, if can be written as

$$N_t = N_0 e^{rt}$$

Where, N_t = population density after time t; N_0 = population density at time zero; r = intrinsic rate of natural increase; e is the base of natural logarithm.

Q 2. Give Verhulst-Pearl logistic growth equation.

Ans. The logistic growth model is given by:

$$dN/dt = rN\,(1-N/K)$$

Where, N is the number (density) of individuals at time t, K is the carrying capacity of the population and r is the intrinsic growth rate of the population.

Q 3. Why is the exponential growth curve be considered as more realistic than the logistic growth curve?

Ans. Since resources of growth for most animal populations are finite and become limiting sooner or later, so the logistic growth model is considered as more realistic.

OR

Name the types of model to measure the growth of population.

Ans. There are two models used to measure the growth of population:

(i) Exponential growth

(ii) Logistic growth.

Very Short Answer Type Questions ↘

Q 1. Give the name of two parasitic plants and two parasitic animals.

Ans. Parasitic plants are *Cuscuta* and *Viscum* and parasitic animals are mites and louse.

Q 2. What is meant by population in demography?

Ans. Population in terms of demography is a set of human in a given area like a village, town, state or country or even all human inhabiting on the planet earth.

Q 3. What do you know about metapopulation?

Ans. A set of local population connected by dispering individuals is called a metapopulation.

Q 4. Give the name of one organism that breed only once in their life time.

Ans. Pacific salmon fish.

Q 5. Why is the problem of predation in plants is more severe than that in animals?

Ans. The problem in severe in case of plants as they cannot move from the predators.

Q 6. Why do predators avoid eating Monarch butterfly? How does the butterfly develop this protective feature?

Ans. The Monarch butterfly is highly distasteful to its predator (birds) because of a special chemical present in its body. It acquires this chemical during its caterpillar stage by feeding on a poisonous weed.

Q 7. What does nature's carrying capacity for a species indicate?

Ans. In nature, a given habitat has enough or limited resources to support a maximum possible number and nature's carrying capacity indicates that no further growth in population is possible.

Q 8. If 8 individuals in a laboratory population of 80 fruit flies died in a week, then what would be the death rate of population for the said period?

(CBSE 2016)

Ans. The death rate will be 0.1 individuals per week.

Q 9. In a pond there were 20 *Hydrilla* plants. Through reproduction 10 new *Hydrilla* plants were added in a year. Calculate the birth rate of the population.

Ans. Birth rate is 0.5 plants per year.

Q 10. Why are cattle and goats not seen browsing on Calotropis growing in the fields?

Ans. Calotropis produces highly poisonous cardiac glycosides. Therefore, cattle and goats do not browse on them.

Q 11. Name the type of association that the genus *Glomus* exhibits with higher plants.

Ans. The association exhibited is Symbiosis/Mycorrhizal /Mutualism.

Q 12. Mention the term used to describe a population interaction between an orchids growing on a forest tree.

Ans. Between an orchid growing on a forest tree, the population interaction is commensalism in which orchid is benefitted and forest tree remains unaffected.

Q 13. State Gause's Competitive Exclusion Principle.

Ans. Gause's Competitive Exclusion Principle states that two closely related species competing for same resources, can not coexist indefinitely (the inferior will be eliminated).

Q 14. Name the interaction between sea anemone and the hermit crab that grows on it.

Ans. Commensalism.

Q 15. What is the interaction called between *Cuscuta* and shoe flower bush?

Ans. Parasitism.

Q 16. What is an interaction called when an orchid grows on a mango plant?

Ans. Commensalism.

Q 17. Pollinating species of wasps show mutualism with specific fig plants. Mention the benefits the female wasps derive from the fig trees from such an interaction.

Ans. The wasp uses the fruit as oviposition and the developing seeds for nourishing its larvae.

Q 18. What is amensalism?

Ans. The mode of interaction between two species where one is harmed and the other is unaffected is called amensalism.

Short Answer Type Questions ↘

Q 1. List any two adaptive features evolved in parasites enabling them to live successfully on their hosts.

Ans. Parasites have evolved the following adaptive features:

(i) Loss of unnecessary sense organs.
(ii) Presence of adhesive organs or suckers to cling on to the host.
(iii) Loss of digestive system.
(iv) High reproductive capacity.

Q 2. If a population growing exponentially double in size in three years. What is the intrinsic rate of increase (r) of the population. *(NCERT)*

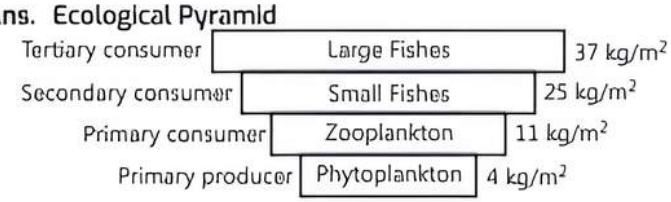
Ans. $t = \frac{\log^2 N}{r}$ or $r = \frac{\log^2 N}{t} = \frac{0.7931}{3} = 0.2643$

Intrinsic increase rate = $0.2643 \times 100 = 26.43\%$

Q 3. Biomass of a standing crop of phytoplankton is 4 kg/m^2 which supports a large standing crop of zooplankton having a biomass 11 kg/m^2. This is consumed by small fishes having biomass 25 kg/m^2 which are then consumed by large fishes with the biomass 37 kg/m^2.

Draw an ecological pyramid indicating the biomass at each stage and also name the trophic levels. Mention whether it is an upright or inverted pyramid. *(CBSE SQP 2023-24)*

Ans. Ecological Pyramid



This pyramid is an Inverted Pyramid of Biomass.

Q 4. Use the information provided in the table given below to answer the following questions:

Trophic level	Net Production ($kJm^{-2}y^{-1}$)	Respiration ($KJm^{-2}y^{-1}$)
Top Carnivore	50	35
Carnivores	420	378
Herbivores	4490	4041
Producers	45000	40,367

(i) Calculate the gross primary productivity.

(ii) Analyze the trend in the Net production from producers to Top carnivore. Give a reason for your observation. *(CBSE SQP 2023-24)*

Ans. (i) Gross Primary Productivity is 45000 + 40367 = 85367 $kJm^{-2}y^{-1}$.

(ii) Net production is gradually reducing as we move from producers to consumers due to heat loss/respiration/10% law.

Q 5. Name the interaction in each of the following:

(i) Cuckoo lays her eggs in the crow's nest.

(ii) Orchid grows on a mango tree.

(iii) Ticks live on the skin of dogs.

(iv) Sea anemone is often found on the shell of hermit crab.

Ans. (i) Brood parasitism

(ii) Commensalism; *Orchid* is an epiphyte

(iii) Parasitism; ticks are ectoparasites

(iv) Commensalism.

Q 6. Lichen is considered as a good example of obligate mutualism. Explain.

Ans. Lichen is considered as a good example of obligate mutualism due to the mutualistic relationship between the fungi and algae or cyanobacteria in lichens. The alga prepares food, while fungus helps in the absorption of nutrients and also provides protection.

Q 7. The clown fish lives among the tentacles of sea anemone. What is this interaction between them called and why?

Ans. This interaction is called commensalism. The sea anemone has stinging tentacles. The clown fish gets protection from its predators, which keeps away from the stinging tentacles of the sea anemone. Thus, the clown fish is benefitted, but the sea anemone does not get any benefit nor is it affected.

Q 8. Name the interaction in each of the following.

(i) *Cuscuta* growing on a shoe flower plant.

(ii) Mycorrhizae living on the roots of higher plants.

(iii) Clown fish among the tentacles of sea anemone.

(iv) Koel laying its eggs in crow's nest.

Ans. (i) Parasitism (ii) Mutualism

(iii) Commensalism (iv) Brood parasitism

Q 9. Describe the age structure in a population.

Ans. The age structure of a given population refers to the proportion of individuals of different ages within that population. This aspect is important because many functional aspects of the individuals are related to age.

Q 10. Define population and community.

Ans. (i) **Population:** It refers to the individuals of one species that live in groups in a well-defined geographical area, share or compete for same resources and potentially interbreed.

(ii) **Community:** It is an association of a number of different inter-related populations belonging to different species in a common environment, which can survive in nature.

Q 11. (i) Explain "birth rate" in a population by taking a suitable example.

(ii) Write the other two characteristics which only a population shows but an individual cannot.

Ans. (i) Birth rate is expressed as the number of births per 1,000 individuals of a population per year. For example, in a pond, there were 200 frogs and 40 more were born in a year.

Then, the birth rate of the population will be 40/200 = 0.5 frogs per year.

(ii) The characteristics which only a population shows but an individual cannot, are sex ratio, age distribution, population density, population growth.

Q 12. (i) What is '*r*' in the population equation given: $dN/dt = rN$?

(ii) How do the increase and the decrease in the value of '*r*' affect the population size?

Ans. (i) '*r*' is called intrinsic rate of natural increase.

(ii) Population size increases with increase in '*r*' and it decreases with decrease in '*r*'.

Q 13. Explain Verhulst-Pearl Logistic Growth of a population. *(CBSE 2016)*

Ans. According to Verhulst–Pearl Logistic Growth, a population growing in a habitat with limited resources initially shows a lag phase, followed by phases of acceleration and deceleration and finally an asymptote when the population density reaches the carrying capacity. It is given by the following equation:

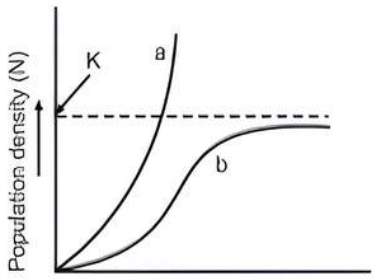
$$dN/dt = rN\,[(K - N)/N]$$

where, N = population density at time t, r = intrinsic rate of natural increase, K = carrying capacity.

COMMON ERROR

Students commonly make mistakes in writing the equation so revise it and its terms properly.

Q 14. Identify the curves 'a' and 'b' shown in the graph given below. List the conditions responsible for growth patterns 'a' and 'b'.



Population growth curve

Ans. Curve 'a' is exponential growth curve. When the resources (food and space) are not limited, this type of growth curve appears.
Curve 'b' is logistic growth curve. When the resources become limited at certain point of time, this type of growth curve appears.

Q 15. Substantiate with the help of one example that in an ecosystem mutualists:
(i) tend to co-evolve and
(ii) are also one of the major causes of biodiversity loss. *(CBSE 2015)*

Ans. (i) In nature, mutualists often co-evolve such as in Mediterranean orchid Ophrys. Ophrys employs sexual deceit to get pollinated by a species of bee. One petal of flower resemble to female bee. If female bee changes its colour pattern ever slightly, the success of pollination will be reduced unless orchid flower co-evolves to maintain resemblance with female bee.
(ii) Co-extinction is one of the 'Evil Quartet' in which organisms with obligatory relationship like plant pollinator, mutualism will result in extinction of one partner if other is eliminated in nature.

Q 16. What is mutualism? Mention any two examples where the organisms involved are commercially exploited in agriculture.

Ans. Interaction between two species in which both are benefitted is called mutualism.

Examples:
(i) *Rhizobium* in the roots (nodules) of legumes.
(ii) *Mycorrhizae* Glomus with the roots of higher plants.

Q 17. (i) Give an example of a genus of fungi that forms mycorrhizal association with plants.
(ii) How does the plant derive benefits from this association? *(CBSE 2023)*

Ans. (i) The fungi which belongs to genus *Glomus* forms mycorrhizial association with plants.
(ii) In such associations, fungi absorbs phosphorus from the soil which is then used by plants as nutrients.

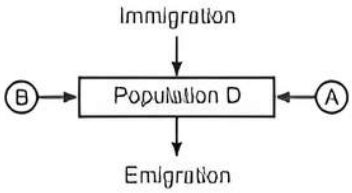
Q 18. An ecologist study an area with population A, thriving on unlimited resources and showing exponential growth, introduced population B and C to the same area.
What will be the effect on the growth pattern of the population A, B and C when living together in the same habitat? *(CBSE SQP 2022, Term-2)*

Ans. This interaction will lead to competition between the individuals of population A, B and C for resources. Eventually the 'fittest' individuals will survive and reproduce.
The resources for growth will become finite and limiting, and population growth will become realistic.

Q 19. With the decline in the population of fig species it was noticed that the population of wasp species also started to decline. What is the relationship between the two and what could be the possible reason for decline of wasps? *(CBSE SQP 2022, Term-2)*

Ans. The relationship between the plant and pollinator is called mutualism. Fig depends on wasp for pollination, and wasp depends on fig for food and shelter.
With the decline in population of figs, wasp loses its source of food and shelter.

Q 20.

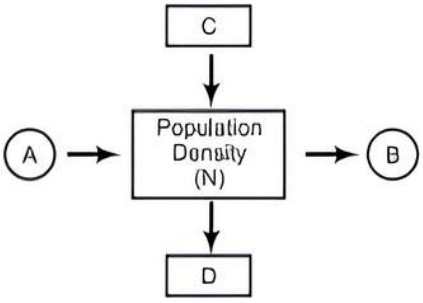


Observe the schematic representation given above and identify A and and B. *(CBSE 2022, Term-2)*

Ans. A = Mortality, B = Natality.

Long Answer Type-I Questions

Q 1. Study the representation given below and answer the following questions:



(i) Identify *A* in it.
(ii) Identify *D* in it.
(iii) When the population density at time t is N as shown above, write the population density at time t + 1 in the equation using appropriate symbols. *(CBSE 2015)*

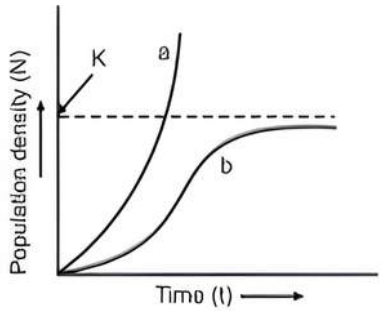
Ans. (i) A = Natality
(ii) D = Mortality
(iii) $N_{t+1} = N_t + ((B + I) - (D + E))$.

COMMON ERROR

Practice writing the equation in the correct order along with the terms involved.

Q 2. Study the graph given below and answer the questions which follow:

(i) The curve 'b' is described by the following equation: What does 'K' stand for in this equation? Mention its significance.



(ii) Which one of the two curves is considered a more realistic one for most of the animal populations?

(iii) Which curve would depict the population of a species of deer if there are no predators in the habitat? Why is it so? *(CBSE 2017)*

Ans. (i) 'K' stands for carrying capacity. Carrying capacity is defined as the maximum number of individuals of a population that can be sustained by the given habitat/environment.
(ii) Curve 'b' is more realistic for most of the animal population.
(iii) Curve 'a'. When the predators are absent, the prey population grows exponentially.

Q 3. Highlight the differences between the population interactions given below. Give an example of each.

(i) Parasitism **(ii) Amensalism**

(iii) Mutualism

Ans.

S. No.	Basis of difference	Parasitism	Amensalism	Mutualism
(i)	Concept	In this interaction one species (parasite) depends on the other species (host) for food and shelter.	In this interaction one species is harmed and the other is neither benefitted nor harmed.	In this interaction both the interacting species are benefitted.
(ii)	Evolution	The interacting species coevolve.	No evolution is observed.	The interacting species coevolve.
(iii)	Examples	*e.g.*, *Cuscuta* is commonly found growing on hedge plants.	*e.g.*, the mould *Penicillium* secretes Penicillin which kills bacteria but the mould is unaffected.	*e.g.*, *Rhizobium* and the legume plants.

TiP

Try to explain the differences in tabular form instead of separate paragraphs.

Q 4. Highlight the differences and a similarity between the following population interactions: competition, predation and commensalism. *(CBSE 2017)*

Ans.

S. No.	Basis of difference	Competition	Predation	Commensalism
(i)	Concept	In this type of interaction, both the species suffer.	In this type of interaction, the predator kills and consumes the prey.	In this type of interaction, one species is benefitted and the other is neither harmed nor benefitted.
(ii)	Reason for occurrence	It occurs due to limited resources between closely related species.	It is the nature's way of transferring energy to higher trophic level.	It is not particularly for any gain of energy or resources.
(iii)	Examples	*e.g.*, In American lakes visiting flamingos and resident fish.	*e.g.*, tiger (predator) and deer (prey).	*e.g.*, sucker fish and shark.

Similarity: All these interactions lead to evolution as the fittest organism survives.

Q 5. Predation is usually referred to as a detrimental association. State any three positive roles that a predator plays in an ecosystem. *(CBSE 2016)*

Ans. Role of predators in an ecosystem:

(i) The predators act as conduits for energy transfer across trophic levels.

(ii) They keep prey populations under control.

(iii) They help in maintaining species diversity in a community by reducing the intensity of competition among prey species.

Q 6. Explain mutualism with the help of any two examples. How is it different from commensalism?

Ans. Mutualism

Mutualism is referred to as the interspecific interaction in which both the interacting species are benefitted.

Examples of mutualism:

(i) Lichens represent close association between fungus and photosynthetic algae or *Cyanobacteria*, where the fungus helps in the absorption of nutrients and provides protection while algae or *Cyanobacteria* prepare the food.

(ii) *Mycorrhizae* are close mutual association between fungi and the roots of higher plants, where fungi help the plant for absorption of nutrients while the plant provides food for the fungus.

In commensalism, one species benefits and the other is neither benefitted nor harmed whereas in mutualism, both the species are benefitted.

Q 7. Explain the following population interactions with the help of one example each:

(i) Brood Parasitism

(ii) Co-evolution of mutualists *(CBSE 2023)*

Ans. (i) Brood Parasitism

It is a type of parasitism in which the parasitic bird lays its eggs in the nest of another bird (host) and lets the host incubate them. The eggs of the parasitic bird have evolved such that they are similar in size and colour to the host's egg. This reduces the chances of detection and ejection of the foreign eggs by the host bird. For example, cuckoo lays eggs in the nest of crow.

(ii) Co-evolution of Mutualists

Mutualism is interaction between two different species in which both are mutually benefited from one another. A very good example of this is seen between flowering plants and their pollinators. Insects are considered as one of the best pollinators. They pollinate the flowers and in turn the flowers provide nectar and pollen as floral rewards. Hence, both species are benefited.

A very close relationship is found between fig plants and female wasps. It has been observed that a particular species of fig is pollinated by a particular species of wasp only. Hence there is a tight one to one relationship. The wasp lays eggs in the fruits of the fig and uses the seeds to feed the developing larvae. While searching for suitable egg laying sites, the wasp pollinates the flowers of fig plants. This relationship between figs and wasps is so profound that they cannot live independently. This process of mutual evolutionary change that occurs between two species as they interact with one another is called co-evolution. Fig plants and wasps are a very good example of co-evolution.

Q 8. Name the type of interaction seen in each of the following examples:

(i) *Ascaris* worms living in the intestine of humans

(ii) Wasp pollinating fig inflorescence.

(iii) Clown fish living among the tentacles of sea-anemone.

(iv) Mycorrhizae living on the roots of higher plants.

(v) Orchid growing on the branch of a mango tree.

(vi) Cuckoo lays eggs in the nest of the crow.

Ans. (i) Parasitism (ii) Mutualism
(iii) Commensalism (iv) Mutualism
(v) Commensalism (vi) Parasitism.

TiP

Learn the basic concepts of all types of population interactions so as to differentiate between them through examples.

Long Answer Type-II Questions

Q 1. (i) What is "population" according to you as a biology student?

(ii) "The size of a population for any species is not a static parameter." Justify the statement with specific reference to fluctuations in the population density of a region in a given period of time. *(CBSE 2019)*

Ans. (i) The term 'population' refers to the group of individuals of a species living together in a group in a well-defined geographical area, sharing or competing for resources and potentially interbreeding. Although the term interbreeding implies sexual reproduction, a group of individuals resulting from even asexual reproduction is also considered a population.

(ii) The size of population of any species is not a static parameter. It keeps changing with time, depending on various factors including food availability, predation pressures, and weather. The population density in a given period can fluctuate due to the following four factors:

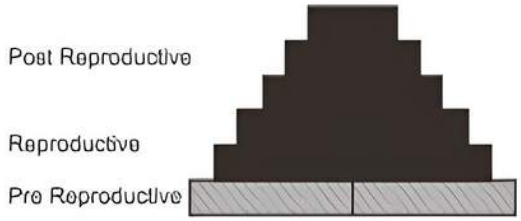
(a) Natality: It refers to the number of births during a given period in the population that are added to the initial density.

(b) Mortality: It refers to the number of deaths during a given period that reduced the size.

(c) **Immigration:** It is the number of individuals of the same species that have come into the habitat from elsewhere during the given period.

(d) **Emigration:** It is the number of individuals who left the habitat and have gone elsewhere.

Q 2. "Analysis of age-pyramids for human population can provide important inputs for long-term planning strategies." Explain.



Identify the type of pyramid given above. Write the identifying feature on basis of which you identified it. *(CBSE 2022, Term-2)*

Ans. The given statement can be explained as:

(i) A population at any given time is composed of individuals of different ages. When the age distribution (per cent individuals of a given age or age group) is plotted for the population, the resulting structure is called age pyramid.

(ii) For human population, the age pyramids generally show age distribution of males and females in a combined diagram.

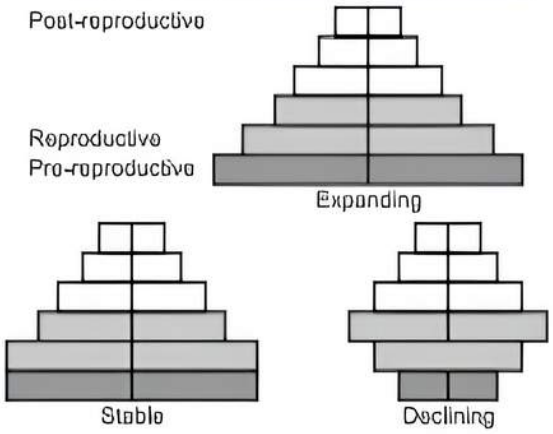
(iii) The shape of the pyramids reflects the growth status of the population and is of three types:

(a) Expanding (Triangular shaped pyramid)

(b) Stable (Bell shaped pyramid)

(c) Declining (Urn shaped pyramid).

(iv) The pyramids also indicate the ratio of pre-reproductive, reproductive and post-reproductive individuals in a population.



Through analysis of the age pyramids of a population, proper planning of health, education, transport, infra-structure, finance, food and employment can be done.

Thus, long-term management of resources can be done so that maximum benefits can be provided to the population.

Q 3. (i) Compare, giving reasons, the J-shaped and S-shaped models of population growth of a species.

(ii) Explain 'fitness of a species" as mentioned by Darwin. *(CBSE 2016)*

OR

Draw and explain a logistic curve for a population of density (*N*) at time (*t*) whose intrinsic rate of natural increase is (*r*) and carrying capacity is (*K*).

Ans. (i) There are two models of population growth:

(a) Exponential growth: This growth occurs where the resources (food and space) are unlimited. The equation can be represented as:

$$\frac{dN}{dt} = (b - d) \times N$$

Let $(b - d) = r$

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

or, $N_t = N_0 e^{rt}$

where, N = population size

N_t = population density after time t,

N_0 = population density at time zero,

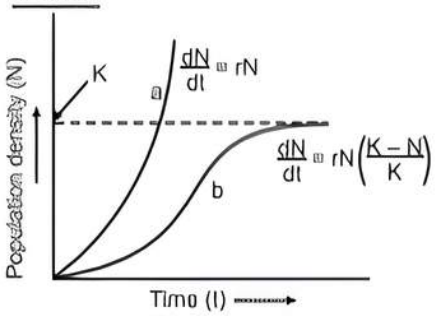
r = growth rate,

b = birth rate and

d = death rate

In this growth, when N in relation to time is plotted on graph, the curve becomes J-shaped.

(b) Logistics growth: This is a realistic approach as the resources become limited at a certain point of time.



- J-shaped curve → exponential growth
- S-shaped curve → logistics growth

Every ecosystem has limited resources to support a particular maximum carrying capacity (K). When N is plotted in relation to time t, a sigmoid-S-shaped curve is obtained and is also called as Verhulst-Pearl logistic growth. The equation is:

$dN/dt = rN((K - N)/K)$

where, N = population density at time t,

r = intrinsic rate of natural increase

K = carrying capacity.

(ii) "Fitness of a species" according to Darwin means reproductive fitness. All organisms after reaching reproductive age have varying degree of reproductive potential. Some organisms produce more offspring and some organism produce only few offsprings. This phenomenon is also called as Differential Reproduction.

Hence the species which produce more offspring's are selected by nature.

Q 4. (i) What is predation? Explain why it is required in a community with rich biodiversity?

(ii) Mention what do the following stand for in the equation given below:

(a) N_{t+1} (b) B and (c) E.

$$N_{t+1} = N_t + [(B + I) - (D + E)]$$

Give an explanation for the above equation.

(CBSE 2015)

Ans. (i) Organism of higher trophic level (predator) feeds on organism of lower trophic level (prey) is called the predation.

It is required in a community with rich biodiversity because of the following reasons:

The population density depends on few basic processes:

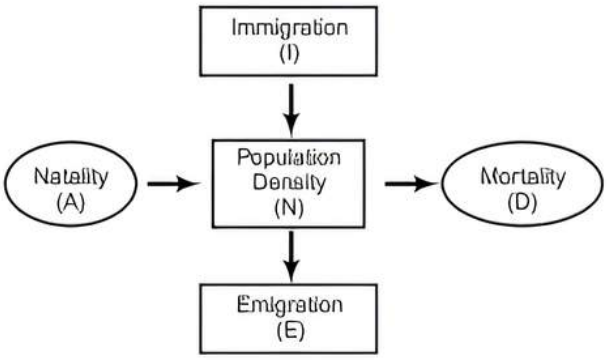
(a) It helps in transfer of energy from one trophic level to the next.

(b) It helps in biological control and to maintain species diversity.

(ii) The population density is given by the following equation: $N_{t+1} = N_t + [(B + I) - (D + E)]$ where N_{t+1} = population density at time $t + 1$, B = birth rate, I = immigration, D = death rate, E = emigration, and N_t = population in the beginning at time t.

This equation shows that the population density will increase, if the number of births plus the number of immigrants $(B + I)$ is more than the number of deaths plus the number of emigrants, i.e., $(D + E)$, otherwise it will decrease.

Q 5. Study the following figure:



(i) Which of the above represents the increase or decrease of population?

(ii) If N is the population density at time t, then what would be its density at time $(t + 1)$? Give the formula.

(iii) In a barn, there were 30 rats. 5 more rats enter the barn and 6 out of the total rats were eaten by the cats. If 8 rats were born during the time period under consideration and 7 rats left the barn, find out the resultant population at time $(t + 1)$.

(iv) If a new habitat is just being colonised, out of the four factors affecting the population growth, which factor contributes the most?

Ans. (i) A and I represents increase of population and D and E represent decrease of population.

(ii) $N_{t+1} = N_t + [(B + I) - (D + E)]$

(iii) Here, $N_t = 30$; $I = 5$; $E = 7$; $D = 6$; $B = 8$

Putting the value in $N_{t+1} = N_t + [(B + I) - (D + E)]$

$$N_{t+1} = 30 + [(8 + 5) - (6 + 7)]$$

$$= 30 + [13 - 13] = 30 + 0 = 30 \text{ rats}$$

(iv) Immigration contributes the most among all the factors affecting the population growth.

Chapter Test

Multiple Choice Questions

Q 1. The maximum growth rate occurs in:

a. lag phase
b. exponential phase
c. stationary phase
d. senescent phase

Q 2. Mycorrhiza is an example of:

a. decomposers
b. endoparasitism
c. symbiotic relationship
d. ectoparasitism

Q 3. In which of the following interactions both partners are adversely afffected?

a. Predation
b. Parasitism
c. Mutualism
d. Competition

Assertion and Reason Type Questions

Directions (Q.Nos. 4-5): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes a, b, c and d as given below.*

a. Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
c. Assertion is true but Reason is false.
d. Both Assertion and Reason are false.

Q 4. **Assertion (A):** Indo-Gangetic plains have high population density.
Reason (R): These have favourable climate and fertile soil.

Q 5. **Assertion (A):** Age-sex structure of human population in France and Sweden forms a steep pyramid.
Reason (R): In countries like Sudan and India, the population is increasing at a rapid rate.

Case Based Questions

Case Study 1

Q 6. It is the mode of interaction between the two species in which one species (parasite) depends on the other species (host) for food and shelter and damages the host.
In this process, one organism is benefitted (parasite), while the other being harmed (host)

Adaptation Methods of a Parasite

(i) Parasite is host-specific in a way that both host and parasite tend to co-evolve.
(ii) Loss of unnecessary sense organs.
(iii) Presence of adhesive organs or suckers.
(iv) Loss of digestive system.
(v) High reproductive capacity.

(i) One species benefit in:
a. parasitism b. predation
c. mutualism d. Both a. and b.

(ii) Parasites that feed on the external surface of the host organism are called:
a. ectoparasites b. endoparasites
c. brood parasitism d. None of these

(iii) Parasites that live inside the host body at different sites are called:
a. ectoparasites b. endoparasites
c. brood parasitism d. None of these

(iv) In parasitism, the organism being harmed is called:
a. parasite b. host c. predator d. producer

Case Study 2

Q 7. Predation is an interspecific interaction, where an animal called predator kills and consumes the other weaker animal called prey. This is a biological control method.
It is the nature's way of transferring energy to the higher trophic levels, which is fixed by plants. For example, tiger and the deer.

Read the given passage carefully and give the answer of the following questions:

(i) What is predator?
(ii) What is prey?
(iii) Give any one important role of predator.

OR

What is the importance of predation in our ecosystem?

Very Short Answer Type Questions

Q 8. Write an example of facultative mutualism.
Q 9. What are the two processes that contribute an increase in population?
Q 10. What is the ecological principle behind the biological control method of managing with pest insects?

Short Answer Type Questions

Q 11. How do you distinguish between ectoparasites and endoparasites?
Q 12. Differentiate between natality and mortality.

Long Answer Type-I Question

Q 13. Certain species of wasps are seen to frequently visit flowering fig trees. What type of interaction is seen between them and why?

Long Answer Type-II Question

Q 14. Define the following terms and give one example of each:
(i) Commensalism (ii) Parasitism
(iii) Camouflage (iv) Mutualism
(v) Interspecific competition.