



Collegedunia NCERT Notes

The Ultimate NCERT Revision Guide for Class 12 Biology — Full-colour diagrams

Chapter 11: Organisms and Populations

Class 12 / 12th Biology — NCERT 2026-27 (New Syllabus)

Also see for this chapter: [NCERT Solutions](#) | [Formula Sheet](#) | [Exemplar Solutions](#)

Why this chapter matters

Chapter 11 opens the Ecology unit and is the single highest-yield ecology chapter for NEET — expect 3–5 direct questions every year on population attributes, growth curves and the six population interactions. Boards lean on the logistic growth derivation, the difference between parasitism and predation, and at least one example each from competition, commensalism and mutualism. The chapter also seeds the next two chapters (Ecosystem, Biodiversity), so a clean understanding pays back across all three.

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1 Background: The Organism and Its Environment

Before populations, the individual. Every organism lives inside a band of physical conditions — temperature, water, light, soil — and the variation in those conditions across the planet drives the diversity of life forms. NCERT 2026-27 has moved most of the abiotic-factor material out of this chapter, but NEET still tests it: tempera-

ture regulation, adaptations of desert organisms, allometric scaling and the four responses to stress remain compulsory background.

1.1 Major Abiotic Components

Four physical variables shape almost every habitat:

- **Temperature** — the most ecologically relevant factor. Mean annual temperature decreases from equator (high) towards poles (low) and from sea level upwards. It controls enzyme kinetics, basal metabolic rate and the geographic limits of every species.
- **Water** — availability of water creates the second great gradient: rain-forest, savannah, desert. For aquatic organisms, salinity (measured in parts per thousand) is the matching variable.
- **Light** — drives photosynthesis. Quantity (intensity) and quality (spectral composition) both vary with depth in water and with canopy layer in a forest.
- **Soil** — texture (sand-silt-clay ratio), pH, mineral nutrients and water-holding capacity together decide which plants can establish; the plants in turn decide which animals can live there.

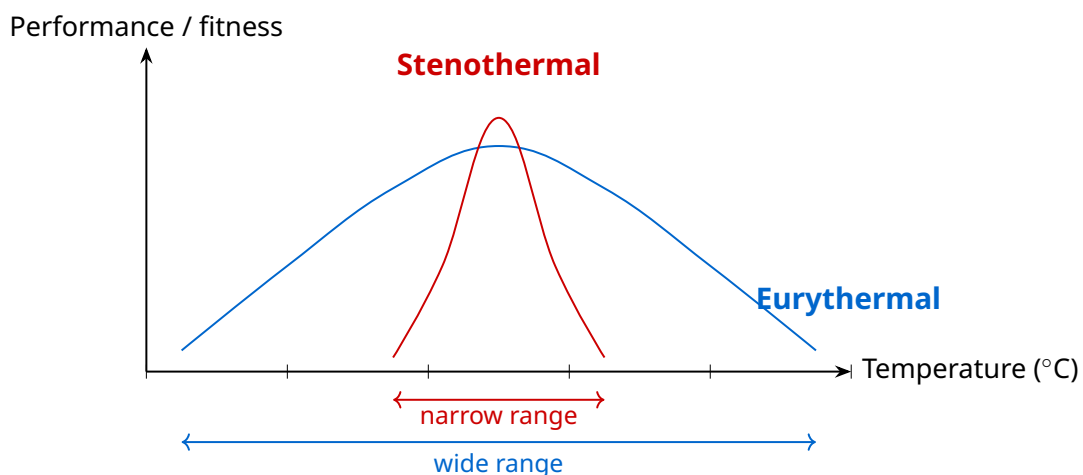
Stenothermal vs Eurythermal — the tolerance range

A species is **steno-** if it tolerates only a narrow range of an abiotic factor, and **eury-** if it tolerates a wide range.

stenothermal \Rightarrow narrow temperature window

eurythermal \Rightarrow wide temperature window

The same prefixes attach to **haline** (salinity) — stenohaline / euryhaline.



1.2 The Four Responses to Environmental Stress

When an external factor (mostly temperature, salinity or water stress) drifts outside an organism's optimum, the body has exactly four options. NEET asks the names and one example each, almost every year.

Regulate | Conform | Migrate | Suspend

Regulate — keep internal milieu constant (mammals, birds; thermoregulation via sweating, panting, shivering).

Conform — internal state tracks the external (99% of animals and almost all plants; body temperature changes with ambient).

Migrate — move temporarily to a more hospitable patch (Siberian cranes flying to Keoladeo NP each winter).

Suspend — shut life down: seeds, spores, hibernation, aestivation, diapause.

Memory aid: *REgulators Climb Mountains*

REgulate → **Conform** → **Migrate** → **Suspend**. Recall this order whenever the question lists four stress responses; the rest of the answer follows.

1.3 Adaptations — Classic NCERT Examples

An adaptation is any heritable trait (morphology, physiology, behaviour) that improves survival or reproduction in a given habitat. These five canonical NCERT examples come back in NEET MCQs in rotation.

- **Kangaroo rat** (*Dipodomys*, North-American deserts) — meets its entire water requirement from internal fat oxidation; produces highly concentrated urine; almost no perspiration.
- **Desert plants** — thick waxy cuticle, sunken stomata, photosynthetic stems, CAM photosynthesis (stomata open at night to fix CO₂ as malate). *Opuntia* has leaves modified into spines.
- **Allen's Rule** — mammals of colder climates have shorter ears and shorter limbs; this lowers the surface-area-to-volume ratio and conserves body heat (Arctic fox versus desert fox).
- **Allometric / altitude adaptation** — humans at > 3500 m suffer altitude sickness because of low O₂ partial pressure. The body compensates by raising red-blood-cell production, increasing breathing rate and binding more haemoglobin.
- **Behavioural & physiological time-outs** — **hibernation** (winter sleep, e.g. bears), **aestivation** (summer sleep, snails, fish), **diapause** (suspended development stage in many zooplankton).

Allen's Rule in one line

Lower SA:V ratio \Rightarrow less heat lost \Rightarrow better cold adaptation. Whenever a NEET stem mentions short ears + short limbs + cold habitat, the answer is Allen's Rule.

Altitude sickness in the Indian Army

Soldiers airlifted from sea level to Siachen (> 5400 m) are kept at staging camps at progressively higher altitudes for 7–10 days. This forced *acclimatisation* lets erythropoietin raise haemoglobin and lets respiratory rate adjust — without it, acute mountain sickness (headache, nausea, pulmonary oedema) can be fatal within hours.

2 Populations and Population Attributes

2.1 What Is a Population?

A **population** is a group of individuals of the same species, living in a well-defined geographical area, that share or compete for similar resources and that can potentially interbreed. Even when reproduction is asexual, the group is still called a population for ecological accounting. All the cormorants in one wetland; all the lotus plants in one pond; all the bacteria in one petri-dish culture — each is a population.

Why study populations and not individuals?

Natural selection operates on populations, not isolated organisms. Population ecology therefore sits at the bridge between ecology and evolution — it links day-to-day numbers (how many tigers in Ranthambore?) with the long-term question (will tigers persist?).

2.2 The Five Population Attributes

An individual has births and deaths, but a *population* has **birth rates** and **death rates** (per-capita rates), a **sex ratio**, an **age distribution** (often plotted as an age pyramid) and a **population density**.

Per-capita rates — worked example

If a pond had 20 lotus plants last year and reproduction added 8 new plants, taking the count to 28, the birth rate is

$$b = \frac{\text{new individuals}}{\text{starting population}} = \frac{8}{20} = 0.4 \text{ offspring per lotus per year.}$$

If 4 of 40 lab fruit-flies died in one week, the death rate is

$$d = \frac{4}{40} = 0.1 \text{ individuals per fruit-fly per week.}$$

- **Birth rate (natality, b)** — births per individual per unit time.
- **Death rate (mortality, d)** — deaths per individual per unit time.
- **Sex ratio** — proportion of males to females (e.g. "60% female, 40% male").
- **Age distribution** — the percentage of individuals in each age class.
- **Population density (N)** — size of the population per unit area (or per unit volume).

2.3 Age Pyramids — Reading the Future of a Population

If the percentage of individuals in each age class is plotted as horizontal bars stacked from youngest (bottom) to oldest (top), the resulting silhouette is an **age pyramid**. For human populations the bar is split down the middle — males on one side, females on the other. The shape immediately tells whether the population is expanding, stable or declining.

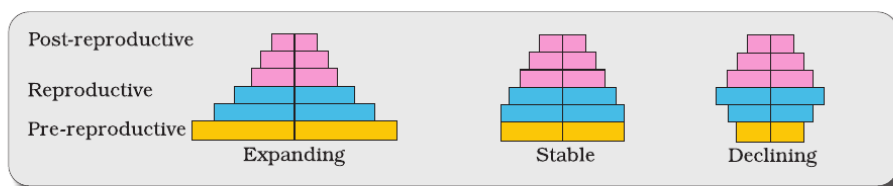


Figure 11.1 Representation of age pyramids for human population

Fig. 11.1 (NCERT): Three classic age pyramids — the broad-based Expanding pyramid (many young pre-reproductive individuals, few old); the column-like Stable pyramid (each age class roughly equal); and the urn-shaped Declining pyramid (narrow pre-reproductive base, broader reproductive middle).

Read the base

Wide base \Rightarrow many children \Rightarrow population will grow. Narrow base \Rightarrow few children \Rightarrow population will shrink in the next generation. The middle (reproductive) and top (post-reproductive) classes only confirm what the base already predicts.

2.4 Measuring Population Density — Not Always a Headcount

The most natural unit of density is total number per unit area. But that unit is meaningless or impossible in many cases:

- One huge banyan with a vast canopy compared with 200 small carrot-grass

plants — a raw count would say carrot-grass dominates, but **per-cent cover** or **biomass** captures the banyan's real ecological role.

- Dense laboratory cultures of bacteria — counting is impossible, so density is reported as **optical density** or **colony-forming units**.
- Tigers in a reserve — elusive and few; density is estimated indirectly from **pug marks** and **faecal pellets**.
- Fish in a lake — the catch per trap (a **relative density**) is enough to compare across lakes.

Choice of density measure

The right measure depends on *why* you are measuring. For comparing two species of very different sizes, use biomass. For an experimental microbial culture, use OD. For a long-term tiger-conservation programme, use camera-trap mark-recapture. "Population density" is not a single number; it is a family of estimates.

3 Population Growth

3.1 The Master Equation — Four Processes that Move N

Population size N at time t never sits still. It is pushed up by **natality** (B , births) and **immigration** (I , arrivals from outside); it is pulled down by **mortality** (D , deaths) and **emigration** (E , departures).

The four-process bookkeeping equation

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

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

N increases when $(B + I) > (D + E)$ and decreases when $(B + I) < (D + E)$.

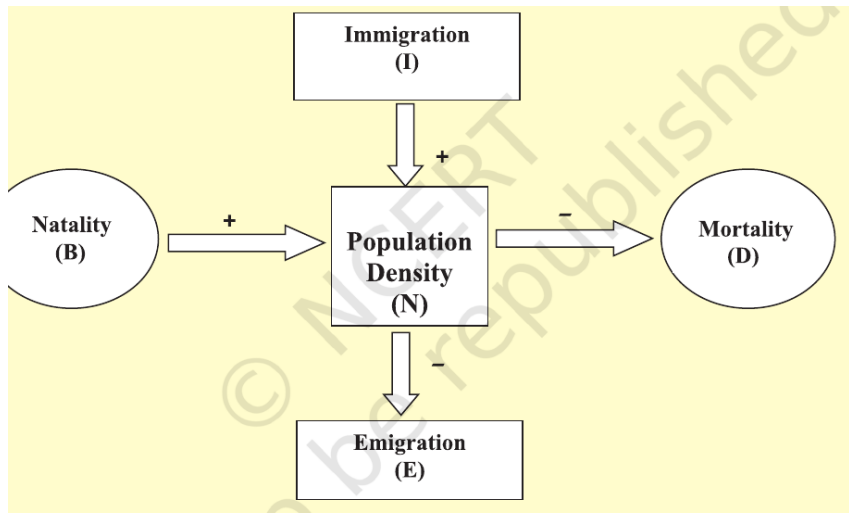


Figure 11.2

Fig. 11.2 (NCERT): The four processes that change population density — natality (B) and immigration (I) add individuals; mortality (D) and emigration (E) remove them. Under normal conditions B and D dominate; I and E become decisive only in special situations (recently colonised habitats, mass dispersal events).

Under ordinary conditions, B and D do most of the work. But when a habitat is newly opened up — a freshly created pond, a recently burnt forest patch — immigration can briefly dominate growth.

3.2 Exponential (Unlimited) Growth

When food and space are unlimited, every individual has the chance to reproduce at the species' *intrinsic* rate, and the population grows in proportion to its current size. Darwin used this very principle to argue why the struggle for existence is inevitable.

Exponential growth equation

Let b and d be the per-capita birth and death rates. Then

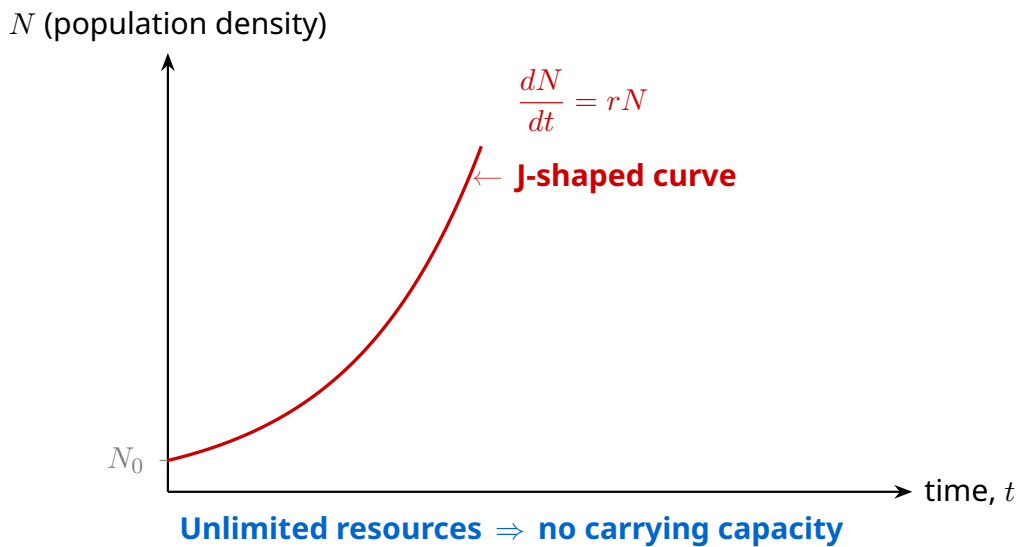
$$\frac{dN}{dt} = (b - d)N = rN$$

where $r = (b - d)$ is the **intrinsic rate of natural increase**. Integrating from N_0 at $t = 0$:

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

$e = 2.71828$ is the base of natural logarithms. A plot of N against t is the famous **J-shaped curve**.

- r for the Norway rat = 0.015 per individual per day.
- r for the flour beetle = 0.12 per individual per day.
- r for the Indian human population in 1981 = 0.0205 per year.



The chessboard parable

A minister asks the king for one wheat grain on the first square, two on the second, four on the third, doubling each square. By square 32 the king already owes more wheat than his kingdom can produce; by square 64 the demand is astronomical. Exponential growth at any positive r behaves exactly the same way — explosively, until something stops it.

3.3 Logistic (Resource-Limited) Growth

No real population can grow exponentially forever. Resources run out, predators arrive, disease spreads — the per-capita growth rate falls as N climbs. The habitat has a maximum number of individuals it can sustain: the **carrying capacity** K .

Verhulst–Pearl logistic equation

$$\frac{dN}{dt} = rN \left(\frac{K - N}{K} \right)$$

where N is population density at time t , r is the intrinsic rate of increase and K is the carrying capacity. The bracketed term shrinks from 1 (when $N \ll K$) to 0 (when $N = K$), throttling growth as the ceiling is approached.

A plot of N versus t for logistic growth is the **S-shaped (sigmoid)** curve, with three phases:

- **Lag phase** — N is small; per-capita resources are abundant; growth is slow because the absolute number of reproducing individuals is small.
- **Acceleration / log phase** — N rises, growth approaches the exponential rate.
- **Deceleration** — resources start to bite, per-capita growth rate falls.
- **Asymptote** — N levels off at K ; $dN/dt \rightarrow 0$.

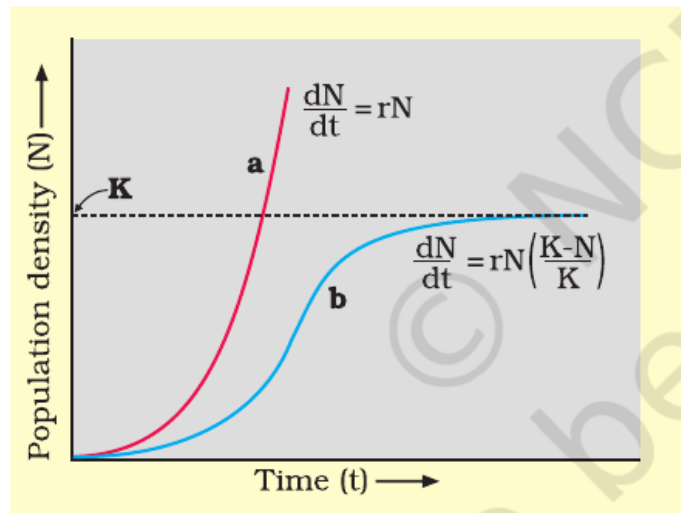


Fig. 11.3 (NCERT): Population growth curves — curve (a) is exponential (J-shape) when resources are not limiting; curve (b) is logistic (S-shape) when resources become limiting. K is the carrying capacity (dashed line). Both follow the same equations stated alongside; logistic is the more realistic of the two.

J or S? Look at the ceiling

A J-curve has no upper bound — it climbs and climbs. An S-curve flattens at K . If a NEET stem says “population stabilised at the carrying capacity”, the answer is logistic; if it says “unlimited resources” or “invasive species in early phase”, the answer is exponential.

Don't conflate r with dN/dt

r is a *per-capita* rate that depends only on the species and its environment — it does not change with N in the exponential model. The *absolute* rate dN/dt does change with N : small N gives small dN/dt even when r is large. Many students confuse the two and write “population growth rate” when they mean “intrinsic rate of natural increase”.

3.4 Life-History Variation

Populations evolve to maximise **Darwinian fitness** (high r). But there is more than one route to high r . Different species have settled on different life-history strategies:

- **Semelparous** — breed once, then die. Pacific salmon, bamboo (mass flowering once every 30–120 years), some butterflies.
- **Iteroparous** — breed many times over a long life. Most mammals and birds.
- **Many small offspring** (*r-selected*) — oysters, pelagic fishes; high mortality of young is the cost.
- **Few large offspring** (*K-selected*) — elephants, whales; heavy parental investment compensates for low fecundity.

There is no single “best” life history

Each strategy is optimal in a particular set of selection pressures: stable habitats favour K-selected, large-offspring species; volatile habitats favour r-selected, many-offspring species. Evolution of life-history traits is one of the most active areas of modern ecology.

4 Population Interactions

No species lives alone. Even a plant that makes its own food needs soil microbes to recycle nutrients and an animal pollinator to set seed. When populations of two different species meet, the outcome for each can be positive (+), negative (–) or neutral (0), giving six possible interaction types (Table 1).

Species A	Species B	Name	Outcome in one line
+	+	Mutualism	both gain (fig-wasp, lichens)
–	–	Competition	both lose (Galapagos goats vs Abingdon tortoise)
+	–	Predation	predator gains, prey killed (tiger-deer)
+	–	Parasitism	parasite gains, host harmed (<i>Plasmodium</i> -human)
+	0	Commensalism	one gains, other unaffected (orchid on mango branch)
–	0	Amensalism	one harmed, other unaffected (<i>Penicillium</i> -bacteria)

Memory aid: *Mutual Competition Pulls People Closer At Meals*

Mutualism, **C**ompetition, **P**redation, **P**arasitism, **C**ommensalism, **A**mensalism — order in NCERT’s Table 11.1. The first letters tell you the sequence of subsections in the chapter.

4.1 Predation

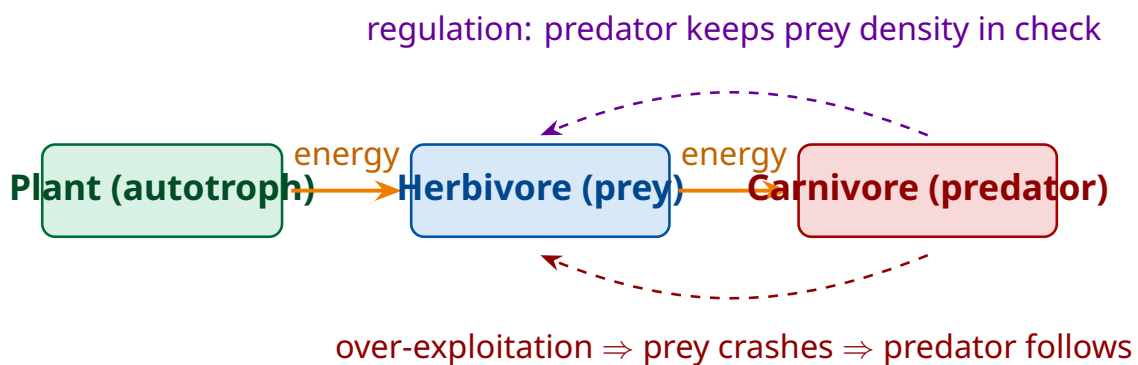
Predation is the consumption of one organism (the *prey*) by another (the *predator*). A tiger eating a deer is the textbook case; a sparrow eating a seed is also predation. Herbivores eating plants are functionally predators of plants. Predation transfers energy fixed by autotrophs up the food chain.

The four ecological roles of predators

1. Energy transfer to higher trophic levels.
2. Keep prey populations in check — without predators, prey numbers explode.
3. Maintain species diversity by limiting competitively dominant prey (Paine's starfish experiment).
4. Act as biocontrol agents — the cactus-moth (*Cactoblastis cactorum*) wiped out invasive prickly-pear *Opuntia* in Australia after 1920.

Predators must not be *too* efficient. Over-exploitation drives the prey extinct and the predator follows. Natural selection therefore favours “prudent predators”. In parallel, prey evolve diverse **defences**:

- **Camouflage / crypsis** — many insects and frogs match the colour of leaves, bark or stones.
- **Aposematism** — bright warning colours signal toxicity (Monarch butterfly stores cardenolides ingested as a caterpillar from milkweed).
- **Mechanical defences** in plants — thorns of *Acacia*, *Cactus*.
- **Chemical defences** in plants — nicotine, caffeine, quinine, strychnine, opium, cardiac glycosides of *Calotropis* (browsing cattle avoid it).



Pisaster — the keystone predator

On the rocky intertidal of the American Pacific Coast, the starfish *Pisaster ochraceus* preys on mussels. When ecologists experimentally removed all starfish from an enclosed patch, the dominant mussel competitively excluded more than 10 other invertebrates within a year. Removing the predator collapsed the community — the original “keystone species” demonstration.

4.2 Competition

Competition occurs when the fitness (measured as r) of one species is significantly lower in the presence of another species. Two surprises from this definition:

- Competing species need not be closely related — in shallow South-American lakes, **flamingoes** (birds) and resident fishes compete for the same zooplankton.
- Resources need not be limiting — in **interference competition**, one species physically prevents the other from feeding even when food is abundant.

Gause's Competitive Exclusion Principle

Two closely related species competing for the same limiting resources cannot coexist indefinitely; the competitively inferior species is eliminated.

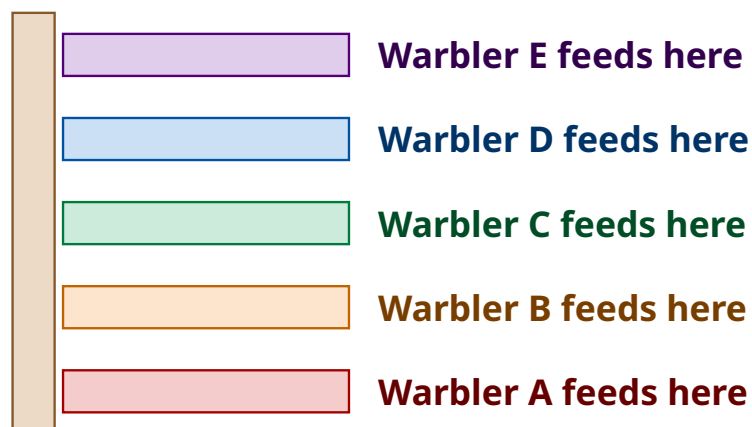
Two pieces of field evidence are routinely cited:

- **Abingdon tortoise** in Galápagos — went extinct within a decade of goats being introduced, apparently because goats browsed more efficiently.
- **Connell's barnacles on Scottish coasts** — the larger *Balanus* dominates the intertidal zone and excludes the smaller *Chthamalus* from that zone.

Competitive release is the inverse experiment: a species restricted to a small range by a superior competitor expands its range dramatically when the competitor is experimentally removed. Connell demonstrated this for *Chthamalus* — remove *Balanus* and the smaller barnacle re-colonises the entire intertidal.

Resource partitioning is the way many closely related species avoid the verdict of Gause's principle. MacArthur showed that five warbler species feeding on the same spruce tree had each evolved to forage on a different vertical layer or branch tip — coexistence without competition.

One tree — five layers — five species (MacArthur)



Gause vs MacArthur in one stem

If the stem says "two species *compete for the same resource* and one disappears" the answer is Gause's competitive exclusion. If it says "two species *coexist by feeding at different layers*", the answer is MacArthur's resource partitioning.

4.3 Parasitism

Parasitism is a +/– interaction where the parasite lives in or on a host, draws nutrition from it and usually weakens it. The parasitic life style guarantees food and shelter, which is why parasitism has evolved independently in almost every taxonomic group.

Hallmark adaptations of parasites

- Loss of unnecessary sense organs (parasites do not need to hunt or seek mates the way free-living organisms do).
 - Loss of digestive system — many endoparasites absorb pre-digested host nutrients across the body wall.
 - Adhesive organs — suckers, hooks, holdfasts to cling to the host.
 - Very high reproductive capacity — a single tapeworm can produce thousands of eggs daily.
 - Complex life cycles — one or two intermediate hosts (*vectors*) are often needed.
- **Human liver fluke** — a trematode that needs *two* intermediate hosts (a snail and a fish) before reaching its primary human host.
 - **Malarial parasite** (*Plasmodium*) — needs the female *Anopheles* mosquito as vector to transmit between humans.
 - **Ectoparasites** live on the body surface — lice on humans, ticks on dogs, copepods on marine fish, the chlorophyll-less parasitic plant *Cuscuta* that twines around hedge plants.
 - **Endoparasites** live inside the body — in the liver, kidney, lung, gut or even red blood cells. Their morphology is greatly simplified; reproductive output is enormous.

Brood parasitism — a behavioural trick

A **brood parasite** bird (e.g. the Asian Koel *Eudynamys scolopaceus*) lays its eggs in the nest of a host species (typically the House Crow) and lets the host incubate and feed the chicks. Co-evolution has made the parasite's eggs mimic the host's eggs in size and colour, reducing the chance that the host will detect and eject them.

Female mosquito is not a parasite

She needs human blood for egg-protein synthesis, but she takes it as a brief blood meal — she does not live in or on the host. The technical definition of parasitism requires a sustained, intimate association.

4.4 Commensalism

In **commensalism**, one species gains and the other neither gains nor loses. The textbook NCERT examples:

- **Orchid on a mango branch** — the orchid (an epiphyte) gains a sunlit perch; the mango tree is unaffected.
- **Barnacles on the back of a whale** — the barnacles get free transport to nutrient-rich water; the whale is unaffected.
- **Cattle egret and grazing cattle** — the cattle stir up insects as they move; the egrets snap up the flushed insects. The cattle are unaffected.
- **Clown fish and sea anemone** — the fish hides among the anemone's stinging tentacles, gaining protection from predators; the anemone is unaffected.

Spot commensalism from amensalism

Both are $/0$ interactions but the sign differs: commensalism is $+/0$ (one species gains), amensalism is $-/0$ (one species is harmed). In a NEET stem, look for the verb — “benefits without harming” is commensalism; “inhibits without being affected” is amensalism.

4.5 Amensalism

Amensalism is a $-/0$ interaction: one species is harmed, the other is unaffected. The classic example is the secretion of an antibiotic (e.g. penicillin) by the mould *Penicillium*, which inhibits surrounding bacteria; *Penicillium* itself is not measurably affected by the bacteria's presence. Allelopathy (one plant releasing chemicals that suppress its neighbours, e.g. *Juglans nigra* — the black walnut — releasing juglone) is another example. Although NCERT lists amensalism in Table 11.1, it is rarely expanded into a paragraph in the main text — but NEET MCQs routinely test the definition.

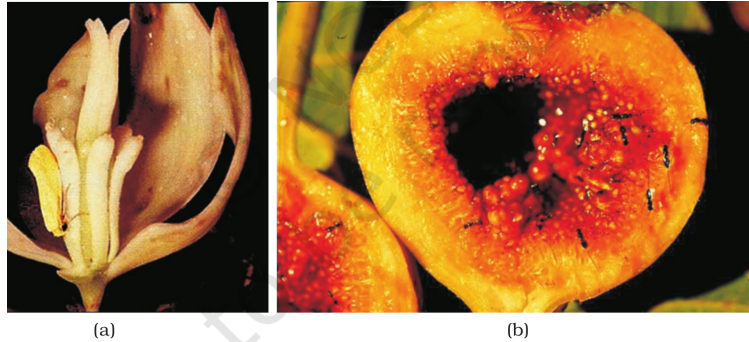
4.6 Mutualism

Mutualism is the $+/+$ interaction — both species gain. NCERT calls the plant-pollinator and plant-microbe mutualisms “the most spectacular and evolutionarily fascinating” examples.

- **Lichens** — intimate association between a fungus (the *mycobiont*, often an ascomycete) and a photosynthetic partner (alga or cyanobacterium, the *photobiont*). The fungus provides shelter and water; the photobiont supplies sugars.
- **Mycorrhizae** — association between fungi and the roots of higher plants. The fungus mines phosphorus and micronutrients from soil; the plant pays in photosynthate. Up to 90% of vascular plants have mycorrhizae.
- **Plant-pollinator mutualisms** — plants offer nectar and pollen; insects, birds and bats carry pollen between flowers. Highly co-evolved partners often show

one-to-one specificity.

- **Seed-dispersal mutualisms** — plants offer juicy fruits; animals eat them and deposit seeds elsewhere.



11.4 Mutual relationship between fig tree and wasp: (a) Fig flower is pollinated by wasp; (b) Wasp laying eggs in a fig fruit

Fig. 11.4 (NCERT): Mutual relationship between the fig tree and its wasp. (a) The fig flower (inside the syconium) is pollinated by the wasp; (b) the same wasp lays eggs inside the developing fig fruit and the larvae feed on a portion of the developing seeds. Each species of fig is pollinated by its own specific wasp species.

The fig-wasp partnership shows tight co-evolution: a fig species can be pollinated only by its partner wasp. The wasp uses the fruit as an oviposition site and the developing seeds as food for its larvae; in return the wasp pollinates the fig inflorescence while searching for laying sites.

Co-evolution can also be exploited. The Mediterranean orchid *Ophrys* uses **sexual deceit**: one petal mimics the female of a particular bee species in size, colour and even surface markings. The male bee “pseudo-copulates” with the petal, gets dusted with pollen, then carries it to the next *Ophrys* flower he visits. The orchid gains pollination; the bee gains nothing (this is technically deception, not mutualism, but the system is sustained by the orchid’s continued mimicry).



Figure 11.5 Showing bee-a pollinator on orchid flower

*Fig. 11.5 (NCERT): A bee acting as a pollinator on an orchid flower. The bee receives nectar or, in the case of *Ophrys*, is deceived by a petal that mimics a female bee.*

Mycorrhiza in Indian agriculture

Inoculating rice and wheat seedlings with arbuscular mycorrhizal fungi (*Glomus* spp.) is now a routine biofertiliser practice. Indian field trials report 15–25% higher phosphorus uptake and 8–12% higher grain yield — all because of one mutualism the farmer can buy in a sachet.

Solve the NCERT Exercises for this Chapter □

5 NEET / JEE Extensions Beyond NCERT

NCERT's rationalised 2026-27 chapter focuses on populations and interactions. NEET, however, regularly asks beyond NCERT — the items below are recurrent extensions worth memorising.

5.1 Population Growth — Quantitative Tricks

Doubling time of a population

The time for an exponentially growing population to double in size is

$$t_{\text{double}} = \frac{\ln 2}{r} \approx \frac{0.693}{r}$$

Worked example: a population doubles in 3 years. Then $r = \ln 2/3 = 0.693/3 \approx 0.231$ per year.

Carrying capacity “half” rule

For the logistic equation, dN/dt is *maximum* when $N = K/2$. This is the inflection point of the S-curve — the moment the population grows fastest in absolute terms.

5.2 Life Tables — The Demographer’s Spreadsheet

A **life table** (or cohort life table) lists, for each age class x , the number of survivors l_x , the probability of surviving from x to $x + 1$, and the average number of female offspring m_x produced by an individual of age x . The product $l_x \cdot m_x$ summed over all ages gives the **net reproductive rate** R_0 :

Net reproductive rate

$$R_0 = \sum_x l_x m_x$$

$R_0 > 1$: population grows. $R_0 = 1$: stationary. $R_0 < 1$: shrinks.

Life tables were not previously in NCERT but are part of competitive-exam scope. They are the quantitative backbone behind every age-pyramid prediction.

5.3 Lotka-Volterra — The Predator-Prey Cycle

The classical predator-prey model (Lotka and Volterra, 1925–26) shows that prey (H) and predator (P) numbers oscillate around an equilibrium:

Lotka-Volterra equations (extension)

$$\frac{dH}{dt} = rH - aHP \quad ; \quad \frac{dP}{dt} = baHP - mP$$

r is prey intrinsic growth; a is predator attack rate; b is conversion efficiency; m is predator death rate. Solving gives a closed loop in the H - P plane: as prey numbers rise, predator numbers rise; as predators boom, prey crash;

predators starve and crash; prey recovers; cycle repeats.

The lynx–snowshoe hare cycle (Hudson Bay Company fur records, 10-year period) is the classic field test of Lotka–Volterra.

5.4 r-selection vs K-selection

A widely tested dichotomy that builds on NCERT's life-history paragraph:

r-selected species	K-selected species
Small body size	Large body size
Short life span	Long life span
Many small offspring	Few large offspring
Little or no parental care	Heavy parental care
Variable, unstable habitat	Stable, predictable habitat
Density-independent mortality	Density-dependent mortality
Examples: bacteria, insects, weeds, oysters	Examples: elephants, whales, humans

5.5 Hibernation, Aestivation, Diapause — Distinguish Cleanly

NEET likes to confuse these. Memorise the season and the typical taxa:

Term	Season	Examples / notes
Hibernation	winter sleep	Bears, ground squirrels, frogs; metabolic rate drops, body temperature plunges.
Aestivation	summer sleep	Snails, lungfish, some amphibians; survive hot dry months in a mucous cocoon.
Diapause	developmental pause	Many insects, zooplankton; a suspended life-cycle stage triggered by daylength or temperature cue.

5.6 Migration — A Worked Indian Example

Siberian cranes fly ~ 5000 km from breeding grounds in Russia to wintering grounds at Keoladeo National Park, Bharatpur. Migration is an *adaptive* response to a temporary stress (Siberian winter); the population returns when conditions improve. Other Indian examples: Amur falcons (Nagaland staging post),

monarch-like Indian crow butterflies, anadromous *hilsa* fish moving from sea to river to spawn.

6 Common Mistakes and Last-Mile Pitfalls

Predation vs parasitism

Both are +/- but parasitism is a sustained, intimate, usually non-lethal association; predation is a brief, lethal kill. A tiger killing a deer is predation; a tapeworm in the deer's gut is parasitism.

"J-shaped" does not mean "unlimited".

J-shape is a *shape*; it merely means the curve rises without an inflection. A population in early logistic growth (very low N) can look J-shaped for a while before the S-bend appears. The defining feature is whether the limit K is approached or not.

The fig-wasp is mutualism, but the orchid-bee in *Ophrys* is deception

Both look like classic mutualism in a photograph, but the bee in *Ophrys* gets nothing in return. NEET stems will quote the case carefully; if the question says "the bee is rewarded with nectar", it is mutualism; if it says "pseudo-copulation", it is deceit.

Lichens are not a single organism

A lichen is a mutualistic *community* of a fungus and a photosynthetic partner. Examiners sometimes write "which kingdom does *Cladonia* belong to?" — the answer is Fungi (because the dominant body is fungal), but the lichen is a partnership, not a kingdom-level taxon on its own.

7 Quick Reference Summary

7.1 Key Equations

Population balance and growth

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

$$\frac{dN}{dt} = rN \quad (\text{exponential}) \quad ; \quad \frac{dN}{dt} = rN \left(\frac{K - N}{K} \right) \quad (\text{logistic})$$

$$N_t = N_0 e^{rt} \quad ; \quad t_{\text{double}} = \frac{\ln 2}{r} \approx \frac{0.693}{r}$$

$$R_0 = \sum_x l_x m_x \quad (\text{net reproductive rate from a life table})$$

7.2 Six Population Interactions — One-Line Recall

- **Mutualism** (+/+) — fig-wasp, lichen, mycorrhiza, pollination, seed dispersal.
- **Competition** (-/-) — Gause's principle, Connell's *Balanus-Chthamalus*, Galápagos goats–Abingdon tortoise.
- **Predation** (+/-) — tiger–deer; sparrow–seed; *Pisaster*–mussel; herbivory.
- **Parasitism** (+/-) — *Plasmodium*, liver fluke, *Cuscuta*, lice, ticks; brood parasitism (Koel–Crow).
- **Commensalism** (+/0) — orchid on mango, barnacle on whale, cattle egret, clown fish–anemone.
- **Amensalism** (-/0) — *Penicillium* antibiotic against bacteria; allelopathy of black walnut.

7.3 Four Responses to Stress — One-Line Recall

- **Regulate** — mammals, birds (constant internal milieu).
- **Conform** — 99% of animals and plants (internal state tracks external).
- **Migrate** — Siberian cranes, monarchs, salmon, Amur falcons.
- **Suspend** — seeds, spores, hibernation, aestivation, diapause.

7.4 Key People to Remember

- **Ramdeo Misra** — “Father of Ecology in India”.
- **Gause** — Competitive Exclusion Principle.
- **Verhulst & Pearl** — logistic growth equation.
- **Connell** — intertidal barnacle experiments.
- **MacArthur** — five warbler species, resource partitioning.
- **Lotka & Volterra** — predator–prey oscillation model.

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