NCERT Exemplar Solutions

Solved NCERT Exemplar Problems for Class 12th Biology, Chapter 11

Chapter 11: Organisms and Populations

About this Chapter

This chapter studies how an organism interacts with its physical and biological surroundings, and how groups of the same species form **populations** that grow, decline and interact with other populations. You will learn the major **abiotic factors** (temperature, water, light, soil), the responses organisms show to cope with them (regulate, conform, migrate, suspend), the attributes of a population (density, natality, mortality, age structure), the exponential and **logistic growth** models, and the six classical inter-specific interactions: mutualism, competition, predation, parasitism, commensalism and amensalism. The Exemplar problems below test these ideas at MCQ, VSA, SA and LA depths suitable for board and NEET-level preparation under the 2026-27 syllabus.

Topics covered: Abiotic factors • Major biomes • Organismic responses • Population attributes • Growth models • Population interactions

Quick Formula Sheet

Exponential growth:
$\frac{dN}{dt} = rN \Rightarrow N_t = N_0 e^{rt}$

Logistic growth (Verhulst–Pearl):
$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$

Per-capita intrinsic rate:
$r = b - d$ (births − deaths per individual)

Binary-fission count:
$N_n = N_0 \cdot 2^n$ (after n generations)

Also see for this chapter: NCERT Solutions | Revision Notes | Formula Sheet

Multiple-Choice Questions

Q 11.1 Autecology is the:

(a) Relation of heterogenous populations 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

SOLUTION

Correct option: (b) Relation of an individual to its environment.

Concept used. **Ecology** is the branch of biology that studies interactions among organisms and between organisms and their physical surroundings. It is studied at four levels of biological organisation: **autecology** (a single species or individual with its environment), **synecology** (a community of populations with its environment), **population ecology** (a group of conspecific individuals) and **ecosystem ecology** (energy flow and nutrient cycling). The prefix *aut-* comes from the Greek *autos* meaning "self", signalling that the focus is on a single self-standing unit (one organism or one species).

Step 1. Decode the term. *Aut-* = self/individual; *-ecology* = study of relations with environment. Together: study of an individual organism (or single species) and its environment.

Step 2. Match to options. Option (a) refers to several different populations — that is synecology. Option (c) is community ecology (synecology). Option (d) is biome-level ecology, an even larger scale. Only option (b) names a single individual.

Step 3. Confirm with example. The study of how one cactus survives in the Thar desert (its water economy, leaf modification, stomatal rhythm) is autecology of *Opuntia*.

Final Answer: Option **(b)**: Relation of an individual to its environment.

EXPERT'S SOLUTION *: Aanya Iyer, M.Sc Botany, Delhi University*

Quick reading. Read the prefix first: *aut-* always means "single/self" in biology (*autotroph* = self-feeder, *autosome* = single-chromosome pair). The moment you see "aut-" + "ecology", the answer must involve a *single* unit — one organism or one species — interacting with its surroundings.

- *Aut-* → self / individual / single species.
- *Syn-* → together / community / many species.

Step 1. Eliminate by scale. Options (a), (c), (d) describe many organisms (populations, community, biome) — all are *synecology*.

Step 2. Only option (b) "an individual to its environment" matches the literal meaning of autecology.

Step 3. Anchor it with a textbook example: Schimper's 1898 work on *Calluna vulgaris* (heather) and a single moor habitat is considered the founding study of autecology.

Why this matters. NEET often tests level-of-organisation vocabulary (individual < population < community < ecosystem < biome < biosphere). Knowing the *aut-/syn-* split makes a whole class of MCQs trivial.

> **Final Answer:** Option **(b)** — autecology = single organism + environment.

☞ **NEET cue**

Whenever an MCQ uses "aut-", "ecology" and four options of which exactly one mentions an individual organism, the individual option is almost always correct. The same trick decodes *autoecology*, *autecism*, *autotomy*, etc.

Q 11.2 **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

SOLUTION

Correct option: (c) A zone of transition between two communities.

Concept used. An **ecotone** is the narrow band of overlap where two adjacent ecological communities meet, e.g. the mangrove between sea and land, the estuary between river and ocean, or the grassland–forest fringe. Ecotones often display the **edge effect**: greater species diversity than either neighbouring community because organisms from both sides plus a few ecotone specialists (edge species) coexist. The word fuses Greek *oikos* (house) and *tonos* (tension).

Step 1. Test each distractor. (a) "Polluted area" is just a degraded patch — no community-transition connotation. (b) "Bottom of a lake" is the benthic or profundal zone, a specific lake stratum, not a community boundary. (d) "Zone of a developing community" describes a sere or successional stage, not an interface.

Step 2. Match the definition. "A zone of transition between two communities" captures the spatial-overlap idea precisely.

Step 3. Anchor with example. The mangrove ecotone hosts both salt- tolerant plants

(*Rhizophora*) and certain land-derived crabs and fish that range into brackish water.

Final Answer: Option **(c)**: A zone of transition between two communities.

☞ **Quick recall**

Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION *: Vivaan Reddy, Ph.D Molecular Biology, NCBS Bangalore*

Structural observation. The word *ecotone* pairs *eco-* (community/house) with *-tone* (tension). The image to hold in your head is two ecosystems pressing against each other along a tense seam — that seam is the ecotone.

Step 1. Define mathematically: if community A has species set S_A and community B has species set S_B, the ecotone contains $S_A \cup S_B \cup S_E$, where S_E is the small set of edge-specialist species.

Step 2. Therefore ecotone diversity $>$ diversity of either A or B alone — the *edge effect*. This is also why conservation biologists protect ecotones disproportionately.

Step 3. Map to options: only option (c) speaks of two communities in contact.

Final Answer: Option **(c)** — the transition seam between two communities.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.

Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.3 **Biosphere is:**

(a) a component in the ecosystem

(b) composed of the plants present in the soil

(c) life in the outer space

(d) composed of all living organisms present on earth which interact with the physical environment

SOLUTION

Correct option: (d) Composed of all living organisms present on earth which interact with the physical environment.

Concept used. The **biosphere** is the global ecological zone occupied by all living things on Earth, together with the parts of the lithosphere (soil/rock), hydrosphere (water) and atmosphere (air) with which they interact. It is the largest, all-inclusive level of biological organisation, above ecosystem and biome. The biosphere extends from the deepest ocean trenches (where chemosynthetic bacteria live) to the high troposphere (where some spores and insects drift).

Step 1. Eliminate (a): the biosphere *contains* ecosystems, it is not a sub-component of one.

Step 2. Eliminate (b): plants in soil are just one of many groups in the biosphere; the definition is far broader.

Step 3. Eliminate (c): no life is known to exist in outer space — the biosphere is Earth-bound.

Step 4. Option (d) names *all* living organisms plus their physical-environment interactions — that matches the textbook definition.

> **Final Answer:** Option **(d)**: All organisms on Earth that interact with the physical environment.

☞ NEET cue

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION *: Karan Banerjee, M.Sc Zoology, Banaras Hindu University*

Picture-first. Imagine zooming out from a single cell on a leaf: cell $\rightarrow$ organism (the plant) $\rightarrow$ population (all plants of that species) $\rightarrow$ community (all populations in the patch) $\rightarrow$ ecosystem (community + abiotic factors) $\rightarrow$ biome (regional ecosystems sharing climate) $\rightarrow$ *biosphere* (every biome combined with their air, water and rock).

Step 1. The biosphere is the outermost concentric shell of life on Earth. Anything alive on the planet is inside it.

Step 2. It is the unit at which we discuss global biogeochemical cycles (carbon, nitrogen, water).

Step 3. Only option (d) captures both inclusivity ("all") and interaction with the physical environment.

Why this matters. The biosphere concept anchors all discussion of global change — climate change, ozone depletion, mass extinction — because each operates at biosphere scale.

> **Final Answer:** Option **(d)** — the entire living layer of Earth.

Q 11.4 **Ecological niche is:**

(a) the surface area of the ocean

(b) an ecologically adapted zone

(c) the physical position and functional role of a species within the community

(d) formed of all plants and animals living at the bottom of a lake

SOLUTION

Correct option: (c) The physical position and functional role of a species within the community.

Concept used. A **niche** is the multi-dimensional description of a species' way of life: where it lives in the habitat (*spatial* or habitat niche), what it eats and what eats it (*trophic* niche), when it is active (*temporal* niche) and how it responds to abiotic gradients of temperature, moisture, light and pH. Habitat answers "where"; niche answers "where + what + when + how". The competitive-exclusion principle (Gause) says that no two species can occupy the same niche indefinitely.

Step 1. Test each option. (a) Ocean surface is just a habitat location — too narrow. (b) "Ecologically adapted zone" is vague and could describe a habitat. (d) Lake-bottom organisms form the benthos — again a habitat, not a niche.

Step 2. Option (c) names both the physical position (habitat aspect) *and* the functional role (feeding, breeding, competing). That is the modern Hutchinsonian definition of niche.

Step 3. Concrete example. Two leaf-warbler species in the same Himalayan forest can coexist because one feeds on insects at the canopy edge while the other gleans from inner branches — same habitat, different niches.

> **Final Answer:** Option **(c)**: Physical position + functional role of a species in the community.

EXPERT'S SOLUTION : *Priya Sharma, M.Sc Botany, Delhi University*

Strategic angle. Don't confuse *habitat* (the address) with *niche* (the profession). Habitat says "the squirrel lives on the oak tree"; niche says "the squirrel lives on the oak, feeds on acorns at dawn and dusk, nests in cavities, is preyed on by hawks, and disperses oak seeds."

Step 1. "Physical position" in option (c) maps to the habitat component.

Step 2. "Functional role" maps to feeding, reproductive timing, predator–prey links, competitive role, etc.

Step 3. Only (c) has both — every other option has only the location part.

> **Final Answer:** Option **(c)** — niche = address + profession.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

♥ Niche vs habitat

NEET frequently sets one option that names a habitat ("coral reef", "mangrove", "benthos") and another that names a functional role. The correct niche option always names *both* components — keep your eye on that pairing.

Q 11.5 According to Allen's Rule, the mammals from colder climates have:

(a) shorter ears and longer limbs
(b) longer ears and shorter limbs
(c) longer ears and longer limbs
(d) shorter ears and shorter limbs

SOLUTION

Correct option: (d) shorter ears and shorter limbs.
Concept used. Allen's Rule (Joel Allen, 1877) states that endothermic (warm-blooded) animals from colder climates tend to have *shorter* appendages — ears, limbs, tails, snouts — than related species from warmer climates. The reason is geometric: appendages have a high surface-area-to-volume ratio and lose heat quickly. Shrinking

them reduces heat loss and helps maintain core body temperature. (Compare **Bergmann's Rule**: cold-climate animals tend to be *larger* overall, because volume rises faster than surface area.)

Step 1. State the principle in symbols. Heat loss $\propto$ surface area A; heat content $\propto$ body volume V. Smaller appendages cut A without cutting V, so the loss-to-content ratio drops.

Step 2. Apply to options. Cold $\Rightarrow$ minimise heat loss $\Rightarrow$ both ears and limbs should be short. Only option (d) has both shorter.

Step 3. Sanity check with examples. Arctic fox has small ears and short limbs; desert fennec fox has huge ears and long limbs. Same genus, opposite extremes — exactly what Allen's Rule predicts.

> **Final Answer:** Option **(d)**: Shorter ears and shorter limbs.

♥ Real-world tie-in

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION *: Ananya Gupta, M.Sc Zoology, Banaras Hindu University*

Quick reading. The mnemonic is "cold = compact". Long thin appendages bleed heat; short stubby ones conserve it. Walrus, polar bear, arctic fox — all noticeably stubby compared with their tropical cousins.

Step 1. Pair Allen with Bergmann. Allen $\rightarrow$ appendage shape; Bergmann $\rightarrow$ overall body size. Cold climates favour large bodies + short appendages together.

Step 2. Eliminate by sign. Anything with "longer" in cold climates contradicts the rule. That kills (a), (b), (c).

Step 3. Option (d) is the only doubly-short choice — it wins.

> **Final Answer:** Option **(d)** — both ears and limbs are short in cold-climate mammals.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors $\rightarrow$ organismic responses" and "population attributes $\rightarrow$ growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.

Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.6 Salt concentration (Salinity) of the sea measured in parts per thousand is:

(a) 10 – 15

(b) 30 – 70

(c) 0 – 5

(d) 30 – 35

SOLUTION

Correct option: (d) 30 – 35 ppt.

Concept used. **Salinity** measures the total dissolved salts in water, expressed in parts per thousand (ppt or ‰). The textbook ranges are: *inland freshwater* < 5 ppt; *open sea* 30–35 ppt (about 3.5% salt by mass); *hypersaline lagoons* > 100 ppt. Organisms tolerant of only a narrow salinity range are **stenohaline**; those tolerant of a wide range are **euryhaline**.

Step 1. Recall the canonical figure for ocean salt content: ≈ 35 g salt per 1000 g of seawater $= 35$ ppt.

Step 2. Match to options. (a) 10–15 is brackish (estuary). (c) 0–5 is fresh inland. (b) 30–70 starts plausibly but extends past any oceanic value. Only (d) 30–35 hugs the textbook range.

Step 3. Cross-check. The chlorinity-based definition gives an average of 34.7 ppt for the open Atlantic — well inside (d).

Final Answer: Option **(d)**: 30 – 35 ppt for the open sea.

EXPERT'S SOLUTION *: Rohit Verma, M.Sc Biotechnology, AIIMS Delhi*

Quick reading. If you only memorise one salinity figure, remember 35 ppt for the open ocean. Estuaries are diluted by river flow; hypersaline lagoons (Dead Sea, Rann of Kutch in summer) are concentrated by evaporation. The chapter table places the sea between those extremes.

Step 1. Eliminate the freshwater band: (c) 0–5 ppt belongs to rivers and inland lakes.

Step 2. Eliminate brackish: (a) 10–15 ppt is typical of estuarine mixing zones.

Step 3. Eliminate over-shoot: (b) 30–70 ppt would include hypersaline lagoons, not the open sea.

Step 4. That leaves (d) 30–35 ppt — the marine textbook range.

> **Final Answer:** Option **(d)**.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

☞ **Salinity bands**

Freshwater $<$ 5 ppt | Brackish 5–30 ppt | Sea 30–35 ppt | Hypersaline $>$ 100 ppt.

Q 11.7 Formation of tropical forests needs mean annual temperature and mean annual precipitation as:

(a) 18 – 25°C and 150 – 400 cm

(b) 5 – 15°C and 50 – 100 cm

(c) 30 – 50°C and 100 – 150 cm

(d) 5 – 15°C and 100 – 200 cm

SOLUTION

Correct option: (a) 18–25°C and 150–400 cm.
Concept used. A **biome** is a large climatic region characterised by a distinctive plant community. Tropical rainforests straddle the equator (Amazon, Congo, Western Ghats, Borneo); their defining climate is *warm* (no real winter) and *wet* (rain nearly every month). The textbook gives mean annual temperature $\approx$ 18–25°C and mean annual precipitation $\approx$ 150–400 cm. Combined, these allow continuous primary productivity and the iconic multi-storey canopy.

Step 1. Eliminate the cold options. (b) and (d) start at 5°C — that is temperate or boreal climate, not tropical.

Step 2. Eliminate the dry option. (c) caps precipitation at 150 cm — insufficient for rainforest formation (deserts and dry savannas live there).

Step 3. Eliminate the unrealistic temperature. 30–50°C mean is desert-class, not rainforest.

Step 4. Only (a) keeps both axes in the textbook rainforest band.

> **Final Answer:** Option **(a)**: 18–25°C, 150–400 cm.

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION *: Pranav Joshi, Ph.D Molecular Biology, NCBS Bangalore*

Strategic angle. For biome MCQs, screen the temperature axis first (it has fewer overlaps), then the precipitation axis. Any option whose temperature does not match the tropics (warm, no frost) can be discarded immediately.

Step 1. Temperature screen: tropical means $\approx$ 18–28°C annual mean. Options (b) and (d) fail.

Step 2. Precipitation screen: rainforest needs ≥ 150 cm/yr. Option (c) fails (≤ 150 cm).

Step 3. Option (a) survives both screens.

Why this matters. The same screening idea identifies temperate forest (10–20°C, 75–150 cm) and tundra (-10 to 5°C, < 25 cm) MCQs at a glance.

> **Final Answer:** Option **(a)**.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.8 **Which of the following forest plants controls the light conditions at the ground?**

(a) Lianas and climbers

(b) Shrubs

(c) Tall trees
(d) Herbs

SOLUTION

Correct option: (c) Tall trees.
Concept used. A forest is vertically stratified into layers: *emergent* (the tallest trees breaking through), *canopy* (the continuous main tree cover), *understorey* (smaller trees and shrubs), and *forest floor* (herbs, mosses, leaf litter). Because sunlight enters from above, the canopy formed by the tallest trees filters and intercepts most of the incoming light. Only 1–5% of the surface radiation typically reaches the forest floor in a dense rainforest. Thus the tall trees *control* ground-level light.

Step 1. Identify the light-blocking layer. The plants closest to the sun (i.e. tallest) intercept the most.

Step 2. Quantify. A multi-layered rainforest canopy can absorb $\geq 95\%$ of incident PAR (photosynthetically active radiation), leaving only diffuse light below.

Step 3. Eliminate options. Lianas climb *onto* tall trees; shrubs and herbs grow *under* them. None of these creates the primary ground shade.

> **Final Answer:** Option **(c)**: Tall trees.

EXPERT'S SOLUTION *: Diya Nair, M.Sc Botany, Delhi University*

Picture-first. Visualise standing on the floor of a tropical rainforest. The dimness around you is created by the green roof overhead — that roof is built by tall trees (30–50 m). Shrubs and herbs sit *inside* that shade; they don't make it.

Step 1. The plant that controls a resource is the plant intercepting it first. For light entering from above, that means the tallest layer.

Step 2. Lianas, shrubs and herbs all live in the shadow cast by the tall trees. They respond to the light regime; they do not set it.

Step 3. Hence option (c).

> **Final Answer:** Option **(c)**.

♥ Light → stratification

Light-limitation is the engine of forest structure. It drives why **sciophytes** (shade plants like ferns) dominate the floor and why **heliophytes** (sun plants) crowd the canopy and gaps. The two terms recur in SA Q4.

Q 11.9 **What will happen to a well growing herbaceous plant in the forest if it is transplanted outside the forest in a park?**

(a) It will grow normally

(b) It will grow well because it is planted in the same locality

(c) It may not survive because of change in its micro climate

(d) It grows very well because the plant gets more sunlight

SOLUTION

Correct option: (c) It may not survive because of change in its micro climate.

Concept used. The **microclimate** is the very local set of conditions (light intensity, temperature, humidity, soil moisture, soil pH, mycorrhizal partners) experienced by a plant within a few metres of its rooting site. A forest-floor herb is adapted to dim, humid, cool, mycorrhiza-rich shade. Moving it to a park exposes it suddenly to full sunlight, low humidity, higher temperature and different soil microflora. Without time to acclimate (or genetic plasticity), it is likely to wilt and die.

Step 1. Compare conditions. Forest floor: ~ 1–5% PAR, 80– 95% relative humidity, 5–10°C cooler in summer than open ground, soil rich in symbiotic fungi. Park: full 100% PAR, 40–60% humidity, hotter, often compacted soil with reduced mycorrhiza.

Step 2. Predict the response. A shade-loving **sciophyte** suddenly thrust into full sun suffers photo-inhibition, scorch and water stress.

Step 3. Eliminate distractors. (a), (b) and (d) all assume the plant will be fine; ecology says otherwise. Same locality $\neq$ same microclimate.

Final Answer: Option **(c)**: It may not survive because of change in its microclimate.

☞ **Strategic shortcut**

Where the question hands you a sign signature $(+, -$ etc.$)$ or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION *: Tara Mehta, M.Sc Microbiology, JNU*

Strategic angle. The trap option here is (b) — "same locality". Locality (the patch of city the plant is in) is not the same as microclimate (the few cubic metres immediately around the plant). Two spots 20 m apart in the same neighbourhood can have dramatically different microclimates.

Step 1. Microclimate has four axes: light, temperature, humidity, soil. Move a plant and you usually change at least three of them.

Step 2. Forest herbs are sciophytes; parks are sun-baked. The light axis alone is fatal.

Step 3. Hence option (c) — survival is uncertain because the microclimate has changed, even though the geographic locality hasn't.

Final Answer: Option **(c)**.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.

Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.10 If a population of 50 Paramoecium present in a pool increases to 150 after an hour, what would be the growth rate of population?

(a) 50 per hour

(b) 200 per hour

(c) 5 per hour

(d) 100 per hour

SOLUTION

Correct option: (d) 100 per hour.

Concept used. Absolute **population growth rate** is the change in number of individuals per unit time:

$$\text{Growth rate} = \frac{\Delta N}{\Delta t} = \frac{N_t - N_0}{t}.$$

Here ΔN is the change in population, N_0 the initial population, N_t the population after time t. The unit is "individuals per unit time". Do not confuse this with *per capita* (per individual) growth rate, which is asked separately in Q11.

Step 1. Identify the data. $N_0 = 50$, $N_t = 150$, $t = 1$ hour.

Step 2. Compute the change in population:

$$\Delta N = N_t - N_0 = 150 - 50 = 100.$$

Step 3. Apply the formula:

$$\frac{\Delta N}{\Delta t} = \frac{100}{1\,\text{h}} = 100 \text{ individuals per hour}.$$

Step 4. Cross-check against options. (a) $50/\text{h}$ would be half the change. (b) $200/\text{h}$ is the new total mis-read as a rate. (c) $5/\text{h}$ is off by a factor of 20. Only (d) matches.

> **Final Answer:** Option **(d)**: 100 individuals per hour.

EXPERT'S SOLUTION *: Aditya Singh, M.Sc Biotechnology, AIIMS Delhi*

Quick reading. Two-word recipe: *change-over-time*. Subtract start from end, divide by elapsed time — done.

Step 1. $\Delta N = 150 - 50 = 100$ paramoecia.

Step 2. $\Delta t = 1$ hour.

Step 3. Rate $= \Delta N/\Delta t = 100/\text{h}$.

Why this matters. Always check whether the question asks for *absolute* rate (individuals/time) or *per-capita* rate (rate/N_0). Q10 wants absolute; Q11 wants per-capita on the *same* data — they have different answers.

> **Final Answer:** Option **(d)** — 100 paramoecia per hour.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

☞ **Absolute vs per-capita**

Absolute rate: $\dfrac{\Delta N}{\Delta t}$ in individuals/time.

Per-capita rate: $\dfrac{1}{N_0}\dfrac{\Delta N}{\Delta t}$, a pure number (or %) — see Q11.

Q 11.11 **What would be the per cent growth or birth rate per individual per hour for the same population mentioned in the previous question (Question 10)?**

(a) 100

(b) 200
(c) 50
(d) 150

SOLUTION

Correct option: (b) 200.
Concept used. Per-capita (per individual) growth rate is the absolute growth rate divided by the starting population, then multiplied by 100 to express it as a percentage:

$$b\ (\text{or } r) = \frac{1}{N_0} \cdot \frac{\Delta N}{\Delta t} \times 100\,\%.$$

For a single time step, it answers: "On average, how many new individuals were produced per existing individual per unit time, in %?" This is the symbol r in the exponential growth equation $dN/dt = rN$.

Step 1. Identify data from Q10. $N_0 = 50$, $\Delta N = 100$, $\Delta t = 1\,\text{h}$.

Step 2. Compute the absolute per-capita rate (a decimal):

$$\frac{1}{N_0}\frac{\Delta N}{\Delta t} = \frac{1}{50} \times \frac{100}{1} = \frac{100}{50} = 2.0 \text{ per individual per hour}.$$

Step 3. Convert to per cent by multiplying by 100:

$$2.0 \times 100\,\% = 200\,\% \text{ per hour}.$$

Step 4. Cross-check. Each individual on average produced 2 extra paramoecia in one hour, i.e. a $200\,\%$ growth per individual per hour.

Final Answer: Option **(b)**: 200 % per individual per hour.

EXPERT'S SOLUTION : *Ishaan Kapoor, Ph.D Molecular Biology, NCBS Bangalore*

Quick reading. Take the Q10 answer of 100 new individuals/hour and ask: "per existing individual?" Divide by $N_0 = 50$ to get 2.0 per individual per hour. Multiply by 100 to express as a percentage $= 200\,\%$.

Step 1. Absolute rate (from Q10) $= 100/\text{h}$.

Step 2. Per-capita decimal: $100/50 = 2.0$.

Step 3. Per cent: $2.0 \times 100 = 200\,\%$.

Why this matters. Per-capita rate r is the foundation of both exponential ($dN/dt = rN$) and logistic ($dN/dt = rN(K-N)/K$) models. Internalising the calculation makes those equations concrete.

Final Answer: Option **(b)** — 200 % per individual per hour.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors $\rightarrow$ organismic responses" and "population attributes $\rightarrow$ growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

✗ Don't double the wrong base

Many candidates pick (a) $100\,\%$ by dividing 100 by $N_t = 150$ (the final count). The correct denominator is $N_0 = 50$ — the *starting* population.

Q 11.12 **A population has more young individuals compared to the older individuals. What would be the status of the population after some years?**
(a) It will decline
(b) It will stabilise
(c) It will increase
(d) It will first decline and then stabilise

SOLUTION

Correct option: (c) It will increase.
Concept used. An **age pyramid** groups a population into three age classes: *pre-reproductive* (young), *reproductive* (middle), *post-reproductive* (old). The shape predicts the future:

- Broad base (more young), narrow top $\Rightarrow$ expanding (*triangular* pyramid).
- Roughly equal bands $\Rightarrow$ stable (*bell*-shaped).
- Narrow base, broad top $\Rightarrow$ declining (*urn*-shaped).

A population dominated by young individuals will, when they reach reproductive age, produce many more offspring than the older cohorts are removing through mortality. Hence the population grows.

Step 1. Diagnose the pyramid: more young $\Rightarrow$ broad base $\Rightarrow$ expanding pyramid.

Step 2. Predict trajectory: as the broad young cohort enters the reproductive age over the next 10–20 years, births will exceed deaths.

Step 3. Therefore the population will increase, not decline or stabilise.

> **Final Answer:** Option **(c)**: It will increase.

☞ **Quick recall**
Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION *: Kavya Bhat, M.Sc Botany, Delhi University*

Picture-first. Draw the three pyramids in your head. Triangle (broad bottom) → growing. Bell (equal middle) → stable. Inverted urn (narrow bottom) → shrinking. The question states "more young" — that is the triangle.

Step 1. Triangle shape = expanding population (India 2001 census is the standard example).

Step 2. Future birthrate > future deathrate as the broad cohort matures.

Step 3. Net increase ⇒ option (c).

> **Final Answer:** Option **(c)**.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Q 11.13 **What parameters are used for tiger census in our country's national parks and sanctuaries?**
(a) Pug marks only
(b) Pug marks and faecal pellets
(c) Faecal pellets only
(d) Actual head counts

SOLUTION

Correct option: (b) Pug marks and faecal pellets.

Concept used. For elusive forest predators that are difficult to count directly, **indirect-evidence censuses** are used. Tigers leave two reliable signs in the field: *pug marks* (footprint imprints on soft soil, each tiger's pattern is as individual as a fingerprint) and *faecal pellets* called *scats* (size, contents and location reveal identity, diet and territory). In Indian tiger reserves, the All India Tiger Estimation combines pug-mark plaster casts *plus* scat analysis with camera trapping for the most accurate count.

Step 1. Eliminate (d). Direct head counts of a shy, nocturnal, highly territorial carnivore are infeasible in dense forest.

Step 2. Eliminate (a) and (c). Each is only *one* cue; combining both gives much better accuracy and identifies individuals.

Step 3. Confirm with practice: Project Tiger uses pug marks + scats + camera traps (also DNA from scat). The textbook answer is the first two — option (b).

> **Final Answer:** Option **(b)**: Pug marks and faecal pellets.

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION *: Yash Desai, M.Sc Zoology, Banaras Hindu University*

Strategic angle. For elusive species, censuses combine *spoor* (footprints/marks) and *scats* (droppings). Either alone undercounts; together they identify individuals reliably.

Step 1. Pug marks uniquely fingerprint each tiger.

Step 2. Scats add diet and territory data.

Step 3. Combined approach is more accurate than either single cue, and head-counts are impossible in dense forest.

> **Final Answer:** Option **(b)**.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.14 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

SOLUTION

Correct option: (c) Mortality and emigration.

Concept used. Population density N at the next time step is determined by four flows:

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

where B = births (natality), I = immigration in, D = deaths (mortality), E = emigration out. The first two add individuals; the last two remove them. To *necessarily* (i.e. always) reduce density, you need processes that only subtract from N — that is, both D and E together.

Step 1. Test each option against $N_{t+1} = N_t + B + I - D - E$.

Step 2. (a) Natality $>$ mortality gives $B - D > 0$, so density increases. Wrong sign.

Step 3. (b) Immigration $>$ emigration gives $I - E > 0$, so density again increases. Wrong sign.

Step 4. (d) Natality and immigration are both additive — they *increase* density.

Step 5. (c) Mortality D and emigration E both subtract from N. Whatever the absolute numbers, both terms enter with a minus sign, so density falls. That is the only option that *necessarily* decreases density.

Final Answer: Option **(c)**: Mortality and emigration (both subtract from N).

♥ **Real-world tie-in**

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION : *Sneha Pillai, M.Sc Microbiology, JNU*

Strategic angle. Translate the four words to algebra: $+B$, $+I$, $-D$, $-E$. The question asks "which always decreases?" Pick the option that contains only minus terms.

Step 1. B and I have plus signs.

Step 2. D and E have minus signs.

Step 3. Only option (c) lists the two minus terms.

> **Final Answer:** Option **(c)**.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.
Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.
Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.15 **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

SOLUTION

Correct option: (c) 64.

Concept used. Binary fission doubles the cell count each generation: 1 cell → 2 cells → 4 cells → . . . The general formula starting from a single founder is

$$N_n = N_0 \cdot 2^n,$$

where N_0 is the starting number, N_n the count after n generations and 2^n the doubling factor. With $N_0 = 1$, the count after n generations is simply 2^n.

Step 1. Set $N_0 = 1$ and $n = 6$.

Step 2. Substitute:

$$N_6 = 1 \cdot 2^6.$$

Step 3. Compute the power:

$$2^6 = 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 4 \times 4 \times 4 = 64.$$

Step 4. Cross-check options. (a) $128 = 2^7$ (seven generations), too many. (d) $32 = 2^5$ (five generations), too few. (b) 24 does not match any 2^n. Only (c) 64 matches 2^6.

> **Final Answer:** Option **(c)**: $2^6 = 64$ protozoans.

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION *: Aanya Patel, M.Sc Botany, Delhi University*

Quick reading. Six doublings ⇒ $2^6 = 64$. Done.

Step 1. Generation 1: 2 cells. Generation 2: 4. Generation 3: 8. Generation 4: 16. Generation 5: 32. Generation 6: 64.

Step 2. This sequence is 2^n powers of 2.

Why this matters. Doubling is the fastest natural growth mode. In ideal conditions, just 20 generations turns 1 cell into over a million ($2^{20} \approx 10^6$). This is why bacterial contamination scales explosively.

> **Final Answer:** Option **(c)** — $2^6 = 64$.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.16 In 2005, for each of the 14 million people present in a country, 0.028 were born and 0.008 died during the year. Using exponential equation, the number of people present in 2015 is predicted as:

(a) 25 millions
(b) 17 millions
(c) 20 millions
(d) 18 millions

SOLUTION

Correct option: (b) 17 millions.
Concept used. The continuous **exponential growth** equation predicts population size after time t as

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

where N_0 is the starting size, $r = b - d$ is the per-capita intrinsic rate (births minus deaths per individual per year) and t is the elapsed time in years. The constant $e \approx 2.71828$.

Step 1. Identify the data. $N_0 = 14 \times 10^6$ in year 2005; per-capita birth $b = 0.028$/yr; per-capita death $d = 0.008$/yr; $t = 2015 - 2005 = 10$ yr.

Step 2. Compute the intrinsic rate:

$$r = b - d = 0.028 - 0.008 = 0.020 \text{ yr}^{-1}.$$

Step 3. Compute the exponent:

$$rt = 0.020 \times 10 = 0.20.$$

Step 4. Compute the growth factor:

$$e^{rt} = e^{0.20}.$$

Using the Taylor series or a table, $e^{0.20} \approx 1.2214$.

Step 5. Compute N_t:

$$N_{2015} = 14 \times 10^6 \times 1.2214 \approx 17.10 \times 10^6 \approx 17 \text{ millions}.$$

Step 6. Match to options. (a) 25 millions would need $r \approx 0.058$. (c) 20 millions would need $r \approx 0.036$. (d) 18 is close but slightly above the exact value. The textbook-rounded answer is (b) 17 millions.

> **Final Answer:** Option **(b)**: $\approx$ 17 million people in 2015.

EXPERT'S SOLUTION : *Pooja Verma, M.Sc Biotechnology, AIIMS Delhi*

Strategic angle. Three-step recipe: compute r, compute rt, multiply N_0 by e^{rt}.

Step 1. $r = 0.028 - 0.008 = 0.02$/yr.

Step 2. $rt = 0.02 \times 10 = 0.2$.

Step 3. $e^{0.2} \approx 1.22$, so $N_{2015} \approx 14 \times 1.22 \approx 17.1$ million.

Why this matters. The same template handles every population forecasting MCQ: "in T years at rate r, the new size is $N_0 e^{rT}$."

> **Final Answer:** Option **(b)** — $\approx$ 17 million.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.

Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

☞ **Handy e^x values**

$e^{0.1} \approx 1.105$, $e^{0.2} \approx 1.221$, $e^{0.5} \approx 1.649$, $e^1 \approx 2.718$, $e^2 \approx 7.389$.

Q 11.17 Amensalism is an association between two species where:
(a) one species is harmed and other is benefitted
(b) one species is harmed and other is unaffected
(c) one species is benefitted and other is unaffected
(d) both the species are harmed.

SOLUTION

Correct option: (b) One species is harmed and the other is unaffected.
Concept used. The textbook classifies inter-specific interactions by the sign of the effect on each partner:

Interaction	Sp. A	Sp. B	Example
Mutualism	$+$	$+$	Lichen, mycorrhiza
Commensalism	$+$	0	Cattle egret + cattle
Predation	$+$	$-$	Lion + deer
Parasitism	$+$	$-$	Tapeworm + human
Competition	$-$	$-$	Two grasses in a plot
Amensalism	$-$	0	Penicillium + bacteria

The signature of amensalism is therefore one harmed $(-)$, one unaffected (0).

Step 1. Decode. "A-mensalism" literally negates "commensalism"; in commensalism one benefits $(+/0)$, so in amensalism one is harmed $(-/0)$.

Step 2. Match to options. Option (b) "one harmed, other unaffected" is exactly $-/0$.

Step 3. Eliminate others. (a) $-/+$ is parasitism or predation. (c) $+/0$ is commensalism. (d) $-/-$ is competition.

Final Answer: Option **(b)**: One harmed, the other unaffected.

☞ **Strategic shortcut**

Where the question hands you a sign signature $(+, -$ etc.$)$ or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION *: Krishna Iyer, Ph.D Molecular Biology, NCBS Bangalore*

Quick reading. Build a sign table $(+, 0, -)$ for each species and match. Amensalism = $(-, 0)$.

Step 1. One species suffers (sign $-$), the other is indifferent (sign 0).

Step 2. Classic example: *Penicillium* secretes penicillin that kills nearby bacteria, while gaining nothing measurable itself.

Step 3. Only option (b) matches the $-/0$ signature.

> **Final Answer:** Option **(b)**.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.
Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.18 Lichens are association of:
(a) bacteria and fungus
(b) alga and bacterium
(c) fungus and alga
(d) fungus and virus

SOLUTION

Correct option: (c) Fungus and alga.
Concept used. A **lichen** is a textbook example of obligate **mutualism**: the fungal partner (the *mycobiont*, usually an ascomycete) provides the thallus structure, attachment to rock or bark, and absorbs minerals and water; the algal partner (the *phycobiont*, a green alga or cyanobacterium) provides photosynthate (sugars). Neither partner can colonise bare rock on its own. Lichens are sensitive bio-indicators of air pollution because SO_2 kills the alga.

Step 1. Identify the two organisms in a lichen. By definition: a fungus and a photosynthetic partner (alga or cyanobacterium).

Step 2. Match to options. (a) bacterium + fungus and (b) alga + bacterium are wrong. (d) virus is not a free-living partner. Only (c) fungus + alga matches.

Step 3. Confirm with role. Fungus = mycobiont (structure, water uptake); alga = phycobiont (food).

Final Answer: Option **(c)**: Fungus + alga.

☞ **Quick recall**
Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION : *Riya Joshi, M.Sc Microbiology, JNU*

Picture-first. Picture a thin grey crust on a tree trunk: that crust is a fungus wrapped tightly around microscopic algae. The fungus offers a home; the algae cook food. Both win.

Step 1. Fungus + alga is the canonical pairing.

Step 2. Each can survive separately only in lab culture — in nature the partnership is obligate.

Step 3. Hence option (c).

Final Answer: Option **(c)**.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.19 **Which of the following is a partial root parasite?**

(a) Sandal wood
(b) Mistletoe
(c) Orobanche
(d) Ganoderma

SOLUTION

Correct option: (a) Sandalwood.
Concept used. Plant **parasitism** is classified by how much the parasite still photosynthesises and where it attaches:

- **Partial root parasite**: green leaves, makes own carbohydrate, but its roots draw water + minerals from a host root via *haustoria*. Example: *Santalum album* (Sandalwood).
- **Total root parasite**: no chlorophyll, takes everything from host root. Example: *Orobanche*, *Rafflesia*.
- **Partial stem parasite**: green, draws from host stem. Example: *Viscum* (Mistletoe).
- **Saprotroph**: *Ganoderma* is a wood-decay fungus, not a plant parasite at all (and certainly not a root parasite).

Step 1. Eliminate (c) *Orobanche* — total root parasite (no chlorophyll, fully dependent).

Step 2. Eliminate (b) Mistletoe — partial *stem* parasite, attaches to branches.

Step 3. Eliminate (d) *Ganoderma* — saprophytic fungus.

Step 4. Only (a) Sandalwood is a partial *root* parasite: green canopy, but feeds on host-root water and salts via haustoria on its own roots.

> **Final Answer:** Option **(a)**: Sandalwood.

☞ NEET cue

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION : *Dev Chatterjee, M.Sc Botany, Delhi University*

Structural observation. Two axes split this MCQ: (i) partial vs total, (ii) root vs stem. Sandalwood is the unique entry that is both *partial* and *root*-attached.

Step 1. Mistletoe = partial stem.

Step 2. Orobanche = total root.

Step 3. Ganoderma = fungus, not parasite.

Step 4. Sandalwood = partial root $\Rightarrow$ option (a).

> **Final Answer:** Option **(a)**.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors $\to$ organismic responses" and "population attributes $\to$ growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars;

every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.20 Which one of the following organisms reproduces sexually only once in its life time?

(a) Banana

(b) Mango

(c) Tomato

(d) Eucalyptus

SOLUTION

Correct option: (a) Banana.
Concept used. Plants are classified by their reproductive strategy across a lifetime: **semelparous** (also called *monocarpic*) organisms reproduce sexually only once, then die or become vegetative; **iteroparous** (*polycarpic*) organisms reproduce multiple times during their life. The textbook examples of semelparity include *bamboo* (flowers once after 50–100 years), *agave*, and the cultivated *banana* (*Musa*) — after the pseudostem produces its single inflorescence and fruit, that pseudostem dies; the plant continues only via lateral suckers (asexual).

Step 1. Identify the life history of each option.

- Banana: pseudostem flowers and fruits *once*, then dies (sexual reproduction is one-shot).
- Mango: large tree, flowers and fruits every year for decades. Iteroparous.
- Tomato: annual herb, flowers continuously through one season — iteroparous within that season.
- Eucalyptus: tree that flowers many times. Iteroparous.

Step 2. The unique semelparous option is (a) Banana.

Step 3. Confirm: bamboo is a more dramatic example (decades-long wait, then mass flowering and death), but it is not in the options.

Final Answer: Option **(a)**: Banana.

♥ **Real-world tie-in**

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION *: Meera Gupta, M.Sc Botany, Delhi University*

Strategic angle. The hidden vocab is *semelparous* vs *iteroparous*. Search the options for the one plant whose pseudostem dies after a single fruiting cycle.

Step 1. Mango, tomato and eucalyptus all fruit repeatedly during their lives.

Step 2. Banana's pseudostem fruits once and dies (vegetative spread via suckers continues, but *sexual* reproduction occurs only once).

Step 3. Hence option (a).

Why this matters. Semelparity is an extreme energy-allocation strategy: invest *everything* in one reproductive event. Bamboo even synchronises this across a population to satiate seed predators.

> **Final Answer:** Option **(a)** — Banana.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Solve the Regular NCERT Exercises →

Very Short Answer Type Questions

Q 11.21 **Species that can tolerate narrow range of temperature are called ________.**

SOLUTION

Concept used. Organisms are classified by their thermal tolerance range. **Stenothermal** species tolerate only a narrow range of temperatures (Greek *stenos* = narrow); **eurythermal** species tolerate a wide range (Greek *eurys* = wide). The same prefix logic gives stenohaline/euryhaline for salinity.

Step 1. Match prefix to meaning: *steno-* = narrow.

Step 2. Apply to temperature: narrow temperature range ⇒ **stenothermal**.

Step 3. Example: most coral species — they bleach above 30 °C and die below 18 °C.

> **Final Answer:** Stenothermal species.

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION *: Aditi Rao, M.Sc Botany, Delhi University*

Quick reading. Greek prefix *steno-* = narrow. Couple it to *-thermal* (temperature) and the answer writes itself: *stenothermal*.

Step 1. *Steno-* + *thermal* ⇒ narrow temperature tolerance.

Step 2. Pair: *eury-* + *thermal* ⇒ wide temperature tolerance (see Q2).

> **Final Answer:** Stenothermal.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.
Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.22 **What are Eurythermic species?**

SOLUTION

Concept used. Eurythermic (or eurythermal) species are organisms that tolerate a *wide* range of temperatures. The prefix *eury-* (Greek for "wide") is the opposite of *steno-* (narrow, see VSA Q1).

Step 1. Decode *eury-* = wide.

Step 2. Apply to temperature: wide temperature range ⇒ the species can survive across many climatic settings.

Step 3. Examples: humans, cockroaches, common Indian sparrow (*Passer domesticus*) — found from cold Himalayan foothills to hot plains.

> **Final Answer:** Species that tolerate a wide range of temperatures, e.g. humans, cockroach.

☞ **Strategic shortcut**

Where the question hands you a sign signature (+, − etc.) or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION : *Neha Sharma, M.Sc Zoology, Banaras Hindu University*

Strategic angle. Whenever VSA asks for "eurythermic", "eurythermal", "euryhaline", the answer is built by replacing the suffix word with its narrow-vs-wide content.

Step 1. Eurythermic = wide temperature tolerance.

Step 2. Wide tolerance lets the species occupy multiple biomes.

> **Final Answer:** Wide-temperature-range tolerant species.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.

Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.23 **Species that can tolerate wide range of salinity are called ________.**

SOLUTION

Concept used. Salinity tolerance uses the same prefixes: **euryhaline** = wide salinity range, **stenohaline** = narrow salinity range. The suffix -*haline* comes from Greek *halinos* (of salt).

Step 1. Decode *eury-* = wide, -*haline* = salt.

Step 2. Wide salinity tolerance ⇒ **euryhaline**.

Step 3. Examples: salmon (migrates between river and sea), *Tilapia*, many estuarine crustaceans.

> **Final Answer:** Euryhaline species.

☞ Quick recall

Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION *: Ishita Patel, M.Sc Biotechnology, AIIMS Delhi*

Quick reading. Pair the prefix with the salt-suffix: *eury-* + -*haline* = *euryhaline*.

Step 1. Wide salinity = euryhaline.

Step 2. Mirror term: stenohaline = narrow salinity (next question).

> **Final Answer:** Euryhaline.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.24 **Define stenohaline species.**

SOLUTION

Concept used. **Stenohaline** organisms tolerate only a narrow range of salinity. They are typically restricted to one of freshwater *or* marine environments and cannot cross the boundary. Greek *stenos* (narrow) + *halinos* (salt).

Step 1. Apply the steno- prefix to salinity: narrow salt tolerance.

Step 2. Examples: most freshwater fish die in seawater; most marine fish die in freshwater because they cannot regulate osmotic balance.

Step 3. Contrast with euryhaline species (VSA Q3) which cross freely.

> **Final Answer:** Species tolerating only a narrow range of salinity (e.g. goldfish in fresh water).

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION *: Sanya Bhat, M.Sc Microbiology, JNU*

Strategic angle. Use VSA Q3 in reverse: *steno-* + *-haline* = narrow salt tolerance.

Step 1. Most fresh-water fish and most strictly marine fish are stenohaline.

Step 2. Their gill ion-pumps are tuned to one osmotic regime; a change kills them.

> **Final Answer:** Narrow-salinity-range tolerant species.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.25 **What is the interaction between two species called?**

SOLUTION

Concept used. Any biological interaction between members of *two different species* is called an **inter-specific interaction** (or simply *interspecific interaction*). It is distinguished from **intra-specific** interactions, which occur between members of the *same* species (e.g. competition between two lions of the same pride for a kill).

Step 1. Decode the prefixes: *inter-* = between, *intra-* = within.

Step 2. Two different species ⇒ inter-specific interaction.

Step 3. The textbook lists six classical types: mutualism, commensalism, predation, parasitism, competition and amensalism (table in MCQ Q17 solution).

> **Final Answer:** Inter-specific (interspecific) interaction.

♥ **Real-world tie-in**

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION : *Arjun Verma, Ph.D Molecular Biology, NCBS Bangalore*

Quick reading. Two species → *inter-*; one species → *intra-*.

Step 1. "Inter" = between (two parties).

Step 2. Any interaction across the species boundary is *interspecific*.

> **Final Answer:** Interspecific interaction.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Q 11.26 **What is commensalism?**

SOLUTION

Concept used. **Commensalism** is an inter-specific interaction in which one species benefits and the other is neither helped nor harmed (sign signature $+/0$). The benefactor is indifferent; the beneficiary gets food, shelter, transport or protection.

Step 1. Sign table entry: $(+, 0)$.

Step 2. Beneficiary: gains something tangible (e.g. a perch, leftover food, dispersal).

Step 3. Indifferent partner: incurs no measurable cost or benefit.

Step 4. Examples: cattle egret feeds on insects flushed by grazing cattle (egret $+$, cattle 0); barnacles on a whale.

> **Final Answer:** An interaction where one species is benefitted and the other is unaffected.

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION : *Aarav Mehta, M.Sc Botany, Delhi University*

Strategic angle. Read the word: *com-* (together) + *mensa* (Latin for table) — "sharing the table". One eats from the table the other set, without disturbing the meal.

Step 1. One species: gains.

Step 2. Other species: indifferent.

Step 3. Example: orchids growing on mango trees (orchid gets a perch with no harm to the mango).

> **Final Answer:** One benefits, the other is unaffected — sign $(+, 0)$.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.27 **Name the association in which one species produces poisonous substance or a change in environmental conditions that is harmful to another species.**

SOLUTION

Concept used. The interaction described is **amensalism** $(-/0)$: one species releases a chemical or modifies the environment in a way that harms a second species, while itself gaining nothing measurable. A specific subset of amensalism is **antibiosis**, in which the harm is delivered by a metabolic secretion (an *antibiotic* or *allelochemical*).

Step 1. Match the description to the sign table: harm to one (sign $-$), no measurable effect on the producer (sign 0).

Step 2. The textbook label for $(-, 0)$ is amensalism; the chemical sub-mode is antibiosis.

Step 3. Examples: *Penicillium* secretes penicillin which kills nearby bacteria (the fungus gains nothing direct); the black walnut tree (*Juglans*) releases juglone, suppressing nearby plant growth.

> **Final Answer:** Amensalism (specifically antibiosis when a chemical is involved).

☞ **Strategic shortcut**

Where the question hands you a sign signature $(+, -$ etc.$)$ or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION *: Siddharth Kapoor, M.Sc Microbiology, JNU*

Quick reading. "Poisonous secretion harming another" $\Rightarrow$ amensalism with an antibiotic mechanism.

Step 1. Producer: not measurably benefited.

Step 2. Target: harmed.

Step 3. Sign table $(-, 0)$ is amensalism by definition.

> **Final Answer:** Amensalism / antibiosis.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.

Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.28 What is Mycorrhiza?

SOLUTION

Concept used. **Mycorrhiza** (literally "fungus-root") is a mutualistic association between certain soil fungi and the roots of higher plants. The fungus envelops or penetrates the root cells, greatly expanding the absorptive surface for water and phosphorus; in return the plant supplies photosynthate (sugars) to the fungus. There are two main types: **ectomycorrhiza** (sheath outside the root, common with pine and oak) and **endomycorrhiza** or *arbuscular mycorrhiza* (penetrates root cortex cells, present in $> 80\%$ of plant species).

Step 1. Identify the partners: a fungus and the root of a vascular plant.

Step 2. Identify the exchange: fungus $\rightarrow$ minerals (especially P) and water; plant $\rightarrow$ sugars (mainly hexoses).

Step 3. Identify the sign: $(+,+) \Rightarrow$ mutualism.

> **Final Answer:** A mutualistic fungus–root association in which the fungus enhances mineral and water uptake while receiving sugars from the plant.

☞ **Quick recall**

Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION *: Rahul Gupta, M.Sc Botany, Delhi University*

Strategic angle. Mycorrhiza is the textbook "poster child" for plant mutualism. Remember three exchanges: *water, P, sugar*.

Step 1. Plant root + soil fungus.

Step 2. Fungus expands the absorptive surface area (often $100\times$).

Step 3. Plant pays back in fixed carbon (sugars).

> **Final Answer:** Mutualistic fungus–root association.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.29 **Emergent land plants that can tolerate the salinities of the sea are called ________.**

SOLUTION

Concept used. **Halophytes** are plants that can grow in saline soils or in salty water (Greek *halos* = salt, *phyton* = plant). **Mangroves** are the classic emergent halophytes along tropical coastlines, with specialised salt-secreting glands and *pneumatophores* (breathing roots).

Step 1. Sea-level salinity $\approx$ 30–35 ppt (see MCQ Q6). Tolerating that needs salt-handling adaptations.

Step 2. Plants with such adaptations are **halophytes** — *Rhizophora*, *Avicennia*, *Sonneratia* in Indian mangroves.

Step 3. These are the "emergent" halophytes the question asks for.

> **Final Answer:** Halophytes (mangroves are the principal emergent halophytes).

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION : *Vivaan Joshi, M.Sc Biotechnology, AIIMS Delhi*

Quick reading. Greek *halo-* (salt) + *-phyte* (plant). Salt-tolerant plant = halophyte.

Step 1. Sea-salinity tolerance + land-emergent habit = mangroves.

Step 2. Mangroves are the canonical halophyte answer.

Final Answer: Halophytes (mangroves).

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.30 **Why do high altitude areas have brighter sunlight and lower temperatures as compared to the plains?**

SOLUTION

Concept used. Two effects of altitude on light and temperature: (i) thinner atmosphere ⇒ less scattering and less ozone-UV absorption, so a higher fraction of solar radiation reaches the ground (especially UV and visible); (ii) thinner air also retains less heat — both the air column and ground radiate heat away faster, and the air pressure drops adiabatically with altitude (~ 6.5°C drop per km, the *environmental lapse rate*).

Step 1. Brighter sunlight: less air mass between the Sun and the ground reduces Rayleigh scattering and atmospheric absorption. Hence higher direct-beam intensity.

Step 2. Lower temperature: lower atmospheric density and pressure ⇒ lower heat-storage capacity and faster radiative cooling. Adiabatic expansion of rising air parcels further drops their temperature.

Step 3. Combined effect: a Himalayan slope at 4000 m is sunnier but colder than the Indo-Gangetic plain at sea level.

Final Answer: Thinner atmosphere lets more sunlight through (brighter) but stores less heat (colder).

♥ Real-world tie-in

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION : *Tara Singh, Ph.D Condensed Matter Physics, TIFR Mumbai*

Picture-first. The atmosphere is a thinning "blanket". At 4000 m the blanket is $\sim 60\%$ as thick. Less blanket: more sun gets in (brighter), but less heat is held (colder).

Step 1. Atmospheric column shrinks with altitude $\Rightarrow$ less scattering, more direct sunlight.

Step 2. Air density drops $\Rightarrow$ less heat retention, lower ambient temperature.

Step 3. Lapse rate ≈ 6.5°C/km.

> **Final Answer:** Thinner atmosphere $\Rightarrow$ brighter sun + colder air.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme. **Recommended practice.** Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Q 11.31 What is homeostasis?

SOLUTION

Concept used. **Homeostasis** is the maintenance of a constant internal environment (temperature, pH, osmotic balance, glucose level) despite a varying external environment. Greek *homoios* (same) + *stasis* (standing). It is achieved by *regulatory* mechanisms: feedback loops involving sensors (receptors), control centres (often the brain) and effectors (muscles, glands).

Step 1. Identify the goal: hold internal variables within narrow limits.

Step 2. Identify the mechanism: negative-feedback loops sense deviations and trigger counter-responses (e.g. sweating when body temperature rises).

Step 3. Classify organisms: **regulators** (homeostatic, e.g. mammals, birds), **conformers** (their internal state tracks the environment, e.g. most invertebrates and fish).

> **Final Answer:** The maintenance of constant internal conditions in the face of a varying external environment.

✗ **Avoid the trap**

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION *: Ananya Desai, M.Sc Zoology, Banaras Hindu University*

Strategic angle. Read the word: *homeo* (same) + *stasis* (standing). The body "stands the same" despite external change.

Step 1. Regulators do it actively (cost energy): mammals, birds.

Step 2. Conformers don't; their internal state shifts with the environment.

> **Final Answer:** Active maintenance of a constant internal milieu.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.32 Define aestivation.

SOLUTION

Concept used. Aestivation (also spelled *estivation*) is a state of summer dormancy that animals or plants enter to survive periods of high temperature and water scarcity. Metabolism, heart rate and respiration drop sharply; the organism remains inactive in a burrow, mud cell or moist crevice until favourable conditions return. It is the summer counterpart of **hibernation** (winter dormancy).

Step 1. Identify the trigger: high temperature and/or drought.

Step 2. Identify the response: lowered metabolic rate, inactivity, often a moist refuge.

Step 3. Examples: snails seal their shells; lungfish encyst in mud; some frogs and Indian desert ground squirrels aestivate.

> **Final Answer:** A summer dormancy with depressed metabolism, used to escape heat and drought.

☞ **Strategic shortcut**

Where the question hands you a sign signature (+, − etc.) or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION : *Aditya Bhat, M.Sc Biotechnology, AIIMS Delhi*

Quick reading. Aestivation = summer hibernation. Same physiology (metabolic suppression), opposite season.

Step 1. Hot/dry trigger → metabolic shutdown → wait it out.

Step 2. Examples: snails, lungfish, some frogs.

> **Final Answer:** Summer dormancy to survive heat and water scarcity.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.

Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.33 What is diapause and its significance?

SOLUTION

Concept used. Diapause is a programmed developmental arrest, most common in insects but also seen in some crustaceans and zooplankton (notably *Daphnia*, the water flea). Triggered by environmental cues such as shortening day length, falling temperature or food shortage, diapause halts growth and reproduction at a specific life stage (egg, larva, pupa or adult). It allows the population to bridge an unfavourable season — winter cold, summer drought, predator surges — without dying out.

Step 1. Distinguish from hibernation/aestivation. Diapause is *anticipatory* (triggered by photoperiod *before* bad conditions arrive) and is a fixed life-stage halt, not a general metabolic slowdown.

Step 2. Identify the significance: synchronises population emergence, survives lethal seasons, can be obligatory (every generation) or facultative (only when cues warrant).

Step 3. Example: many temperate-zone insect eggs and *Daphnia* ephippia overwinter in diapause and hatch in spring.

> **Final Answer:** An environmentally triggered halt in development; significance — it lets the species survive unfavourable seasons.

☞ **Quick recall**

Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION *: Pooja Sharma, M.Sc Zoology, Banaras Hindu University*

Quick reading. Diapause = *anticipated* developmental pause cued by day length. Survival strategy in seasonal climates.

Step 1. Trigger: shortening photoperiod, dropping temperature.

Step 2. Stage: any (egg, larva, pupa, adult).

Step 3. Outcome: bridge unfavourable season, resume in spring.

> **Final Answer:** A cue-triggered developmental arrest that lets species bridge harsh seasons.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.34 What would be the growth rate pattern, when the resources are unlimited?

SOLUTION

Concept used. When resources (food, space, water, nutrients) are unlimited, populations grow by **exponential growth** following $dN/dt = rN$. Plotted against time, the curve is *J-shaped* — slow start, then runaway increase with no upper ceiling. The integrated form is $N_t = N_0e^{rt}$.

Step 1. Identify the model: unlimited resources ⇒ no carrying-capacity term, growth is pure rN.

Step 2. Identify the curve shape: continuous doubling produces a J-shape on a linear N vs t plot.

Step 3. Contrast with logistic (S-shape) which appears when resources *are* limited (see LA Q4).

> **Final Answer:** Exponential (J-shaped) growth, $dN/dt = rN$.

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION : *Karan Iyer, Ph.D Molecular Biology, NCBS Bangalore*

Strategic angle. Unlimited resources ⇒ no ceiling ⇒ exponential J-curve. Limited resources ⇒ ceiling K ⇒ logistic S-curve. Two sentences capture both possibilities.

Step 1. Equation: $dN/dt = rN$.

Step 2. Solution: $N_t = N_0e^{rt}$, a J-shape.

> **Final Answer:** Exponential (J-shaped) growth.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.

Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.35 **What are the organisms that feed on plant sap and other plant parts called?**

SOLUTION

Concept used. Animals that eat plants are called **phytophagous** (Greek *phyton* = plant, *phagein* = to eat) or, more generally, **herbivores**. Sap-feeders are a sub-class of phytophages (e.g. aphids, leafhoppers, scale insects, plant bugs).

Step 1. Identify the prefix *phyto-* = plant.

Step 2. Identify the suffix *-phagous* = eating.

Step 3. Combined: plant-eating animals ⇒ phytophagous.

Final Answer: Phytophagous organisms (a sub-class of herbivores).

♥ Real-world tie-in

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION : *Riya Pillai, M.Sc Botany, Delhi University*

Quick reading. *Phyto-* (plant) + *-phagous* (eating). Aphids and grasshoppers are textbook examples.

Step 1. Sap-suckers: aphids, leafhoppers.

Step 2. Tissue-chewers: grasshoppers, caterpillars.

Step 3. Both are phytophagous.

Final Answer: Phytophagous.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Q 11.36 **What is high altitude sickness? Write its symptoms.**

SOLUTION

Concept used. **High-altitude sickness** (*acute mountain sickness*, AMS) is the physiological response of an unacclimatised lowland resident to the reduced *partial pressure of oxygen* at altitudes $> 2400\,\text{m}$. Although the percentage of oxygen in air stays at 21%, the lower atmospheric pressure means fewer oxygen molecules reach the alveoli per breath, producing **hypoxia**. The body responds by hyperventilating and increasing heart rate; with time it boosts red-blood-cell production and capillary density (*acclimatisation*).

Step 1. State the cause: hypoxia from lower pO_2 at altitude.

Step 2. List the symptoms:

- Nausea, vomiting and loss of appetite.
- Fatigue, weakness and dizziness.
- Headache.
- Sleeplessness; shortness of breath.
- Rapid heart rate (tachycardia).

Step 3. Recovery: descend, supplemental O_2, time to acclimatise.

> **Final Answer:** Hypoxia-driven illness at high altitude; symptoms include nausea, fatigue, headache, palpitations and sleeplessness.

EXPERT'S SOLUTION *: Dev Singh, M.Sc Biotechnology, AIIMS Delhi*

Strategic angle. Cause = low oxygen partial pressure; symptoms = the body's hyperventilation/cardiac compensation gone wrong. List 4–5 named symptoms for full marks.

Step 1. Cause: pO_2 falls with altitude even though $\%\ O_2$ is constant.

Step 2. Symptoms: nausea, fatigue, headache, palpitations, sleeplessness.

Step 3. Cure: descent, oxygen, gradual acclimatisation.

> **Final Answer:** Hypoxic mountain illness with nausea, headache, fatigue and palpitations.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

☞ **Acclimatisation timeline**

After 1–3 weeks at altitude, the body increases RBC count (**polycythaemia**) and capillary density, so oxygen delivery per heartbeat rises. Sherpas, Tibetans and Andean populations have genetic adaptations on top of this.

Q 11.37 **Give a suitable example for commensalism.**

SOLUTION

Concept used. Commensalism (recall VSA Q6) requires sign signature $(+, 0)$: one species benefits, the other is unaffected. Two textbook examples for India-context answers:

- **Cattle egret** (*Bubulcus ibis*) follows grazing cattle and feeds on insects flushed out of the grass. The bird benefits $(+)$; the cattle are indifferent (0).
- An **epiphytic orchid** growing on a mango tree branch. The orchid gets a sunlit perch $(+)$; the mango is unaffected (0) so long as the orchid doesn't draw water or nutrients from the host.

Step 1. Pick one example.

Step 2. State which species benefits, which is unaffected.

> **Final Answer:** Cattle egret feeding on insects flushed by grazing cattle.

✗ **Avoid the trap**

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION : *Aanya Banerjee, M.Sc Zoology, Banaras Hindu University*

Quick reading. Pick whichever pair you can describe in one line. Cattle egret + cattle is the easiest because the egret's benefit (insects) is obvious and the cattle clearly don't care.

Step 1. Beneficiary: cattle egret (gets food).

Step 2. Indifferent: cattle (no measurable cost or benefit).

> **Final Answer:** Cattle egret + grazing cattle.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.
Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.38 **Define ectoparasite and endoparasite and give suitable examples.**

SOLUTION

Concept used. Parasites are classified by where they live on or in the host:

- **Ectoparasite** (Greek *ektos* = outside): lives on the host's body surface — skin, fur, scales, feathers. Examples: head louse (*Pediculus humanus*), human flea, ticks on cattle, copepod ectoparasites of marine fish.
- **Endoparasite** (*endon* = within): lives inside the host body — in the gut, liver, lung, blood. Examples: *Ascaris* (intestinal roundworm), tapeworm (*Taenia*), *Plasmodium* (malarial parasite in blood and liver).

Step 1. Decode prefix: *ecto-* = outside, *endo-* = inside.

Step 2. Apply to parasite location.

Step 3. Quote one named example for each.

> **Final Answer:** Ectoparasite lives on the host surface (e.g. head louse); endoparasite lives inside the host (e.g. *Ascaris*).

☞ **Strategic shortcut**

Where the question hands you a sign signature (+, − etc.) or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION : *Yash Nair, M.Sc Microbiology, JNU*

Strategic angle. One-word distinction + one named example each is enough.

Step 1. Ecto = outside; head lice, ticks.

Step 2. Endo = inside; tapeworm, *Plasmodium*.

> **Final Answer:** Ecto = surface (lice); Endo = internal (tapeworm).

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.39 **What is brood parasitism? Explain with the help of an example.**

SOLUTION

Concept used. Brood parasitism is a reproductive strategy in which one bird species lays its eggs in the nest of another (host) species and lets the host raise the parasite's chicks as its own. The parasite saves the energy of nest-building and chick-care; the host loses fitness because its own chicks usually starve or are evicted by the larger, faster-growing parasite chick. The classic example is the **cuckoo** (*Cuculus canorus*, or the Asian Koel *Eudynamys scolopaceus*) laying eggs in the nest of a crow.

Step 1. Identify the actors: parasite bird (cuckoo/koel) and host bird (crow, warbler, dunnock, etc.).

Step 2. Describe the mechanism: cuckoo lays its egg in the host nest, often quickly while the host is away; the egg often mimics the host's egg colour and size; the parasitic chick hatches earlier and either ejects host eggs or out-competes host chicks for food.

Step 3. Identify the cost–benefit: parasite + (free childcare); host − (lost reproductive output). Hence brood parasitism is a form of parasitism, signature $(+, -)$.

> **Final Answer:** One species lays its eggs in another species' nest, e.g. cuckoo laying eggs in a crow's nest.

EXPERT'S SOLUTION : *Sneha Reddy, Ph.D Molecular Biology, NCBS Bangalore*

Picture-first. A cuckoo sneaks an egg into a crow's nest. The crow incubates and feeds the cuckoo chick, often at the cost of its own brood. That is brood parasitism in one sentence.

Step 1. Parasite saves: nest-building, incubation, chick-feeding.

Step 2. Host loses: its own chicks' survival.

Step 3. Egg-mimicry has co-evolved in many host–cuckoo systems.

> **Final Answer:** Cuckoo–crow egg parasitism.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.
Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

♥ Co-evolution

Brood parasitism drives an evolutionary "arms race": host birds evolve to recognise and reject foreign eggs; parasites evolve closer egg mimicry. This is one of the cleanest natural examples of co-evolution in vertebrates.

Short Answer Type Questions

Q 11.40 **Why are coral reefs not found in the regions from West Bengal to Andhra Pradesh but are found in Tamil Nadu and on the east coast of India?**

SOLUTION

Concept used. Coral reefs are built by colonial cnidarians (*Scleractinia*) whose calcium-carbonate skeletons accumulate over centuries. Reef-building corals are *stenohaline* and *stenothermal*: they require salinity ≈ 30–35 ppt, water temperature $> 20\,^\circ$C, and clear, sediment-free water (high light penetration is needed for their symbiotic algae, *zooxanthellae*). Any factor that lowers salinity, raises turbidity, or covers the substrate with mud breaks reef formation.

Step 1. The West Bengal–Andhra Pradesh coastline lies at the mouths of major rivers: the Hooghly–Ganga, Brahmaputra (deltaic outflow into the Sundarbans), Mahanadi, Godavari and Krishna. These rivers deliver huge sediment loads and dilute the coastal water with freshwater.

Step 2. Two reef-blocking effects result. (a) Salinity drops well below the 30–35 ppt range corals tolerate. (b) Turbidity rises sharply, cutting the light reaching the zooxanthellae and smothering polyps with silt.

Step 3. Tamil Nadu and the southern east coast (Gulf of Mannar, Palk Bay) receive far less river-borne sediment and dilution. Salinity stays in the marine range and water clarity supports reef growth, allowing the famous Gulf of Mannar coral reefs.

> **Final Answer:** Heavy river freshwater + sediment from the Ganga–Brahmaputra–Mahanadi–Godavari–Krishna delta system lowers salinity and raises turbidity along Bengal–Andhra, blocking reef growth; Tamil Nadu's clearer, saltier waters allow it.

☞ **Quick recall**

Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION : *Aditi Mehta, M.Sc Botany, Delhi University*

Strategic angle. Use the two-axis test: corals need *high salinity and clear water*. The Bengal–Andhra coast fails both because of giant river deltas; Tamil Nadu satisfies both because no comparable river dumps sediment there.

Step 1. River-dominated coast $\Rightarrow$ low salinity + high turbidity $\Rightarrow$ no reefs.

Step 2. River-poor coast (Gulf of Mannar) $\Rightarrow$ marine salinity + clear water $\Rightarrow$ reefs thrive.

Final Answer: Freshwater dilution and silt from delta rivers exclude reefs in WB–AP; clear marine water permits them in Tamil Nadu.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.
Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.
Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.
Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.41 **If a fresh water fish is placed in an aquarium containing sea water, will the fish be able to survive? Explain giving reasons.**

SOLUTION

Concept used. Body fluids of a freshwater fish are *hypertonic* to fresh water (higher salt concentration inside than outside), so the fish actively absorbs salts through its gills and excretes copious dilute urine. Seawater, in contrast, is *hypertonic* to the fish's body fluids (≈ 35 ppt vs ≈ 10 ppt). Placed in seawater, the osmotic gradient reverses: water rushes *out* of the fish's body by **osmosis** and salts diffuse *in*. The fish has no physiological machinery (no salt-excreting chloride cells, no concentrated urine) to reverse this — it is **stenohaline**.

Step 1. State the osmotic situation. Fish body fluids: ~ 10 ppt salt. Seawater: ~ 35 ppt salt. Net water movement: out of fish, by osmosis through the gills.

Step 2. State the ionic situation. Salts diffuse *in* through the gills along their concentration gradient.

Step 3. State the physiological limit. The freshwater fish's gills and kidneys are tuned to dilute external water; they cannot excrete concentrated salt or retain water in seawater.

Step 4. Outcome. The fish loses water (cellular dehydration) and accumulates salt; it dies within hours.

> **Final Answer:** No. The fish is stenohaline; in seawater it loses water by osmosis and absorbs salt against its physiology, and dies.

EXPERT'S SOLUTION *: Rohit Patel, M.Sc Biotechnology, AIIMS Delhi*

Strategic angle. Compare the osmotic concentrations. Freshwater fish body $>$ freshwater medium $<$ seawater. The fish is on the wrong side of the osmotic balance in seawater.

Step 1. Inside the fish: ~ 10 ppt; outside in seawater: ~ 35 ppt.

Step 2. Water leaves; salt enters; both kill the cell.

Step 3. Stenohaline = no rescue physiology.

> **Final Answer:** No — osmotic dehydration plus salt overload kill the fish.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.
Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors $\rightarrow$ organismic responses" and "population attributes $\rightarrow$ growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

✗ Don't say "the fish chokes"

The cause of death is osmotic, not respiratory. The gill surface still exchanges oxygen — it just simultaneously bleeds water and absorbs salt.

Q 11.42 **Why do all the fresh water organisms have contractile vacuoles whereas majority of marine organisms lack them?**

SOLUTION

Concept used. A **contractile vacuole** is a membrane-bound organelle in unicellular freshwater protists (*Paramoecium*, *Amoeba*) that periodically expels excess water to prevent cell lysis. It is essentially an osmoregulatory pump. Need for it depends on the osmotic gradient between the cell and its medium.

Step 1. Freshwater cells: cytoplasm is hypertonic relative to fresh water $\Rightarrow$ continuous water influx by osmosis. The cell would burst if it could not pump water out. Hence the contractile vacuole.

Step 2. Marine cells: cytoplasm is roughly isotonic (or slightly hypotonic) to seawater $\Rightarrow$ little or no net water influx. No need for a contractile vacuole — and in many marine protists it is absent or much less active.

Step 3. Conclusion: contractile vacuoles evolved as a freshwater adaptation; marine ancestors lacked the osmotic pressure that necessitates them.

> **Final Answer:** Freshwater is hypotonic to the cell, so water rushes in and must be pumped out by the contractile vacuole. Seawater is roughly isotonic, so no pump is needed.

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION : *Pranav Reddy, Ph.D Molecular Biology, NCBS Bangalore*

Quick reading. Osmotic gradient drives the difference. Freshwater = inflow problem $\Rightarrow$ pump it out; seawater = no inflow $\Rightarrow$ no pump.

Step 1. Freshwater cell: osmotic water influx is constant.

Step 2. Marine cell: gradient is negligible.

Step 3. Hence the contractile vacuole is a freshwater-specific organelle.

> **Final Answer:** The contractile vacuole counteracts continuous osmotic water entry — a problem only in fresh water.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in

the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Q 11.43 **Define heliophytes and sciophytes. Name a plant from your locality that is either heliophyte or sciophyte.**

SOLUTION

Concept used. Plants are classified by their light requirement: **heliophytes** (Greek *helios* = Sun) thrive in full sunlight and are intolerant of deep shade; **sciophytes** (*skia* = shade) thrive in low light and are damaged by direct sun. The split reflects different photosynthetic machinery — high light-saturation point and many chloroplasts per mesophyll cell in heliophytes; low saturation point and grana-rich chloroplasts in sciophytes.

Step 1. Heliophyte definition: sun-loving plants that grow optimally in open, full-sun conditions.

Step 2. Sciophyte definition: shade-loving plants that grow optimally under low light, often the forest understorey.

Step 3. Local examples:

- Heliophyte: *Tridax procumbens* (a common roadside weed), sunflower, mustard, marigold.
- Sciophyte: *Pteris* (table fern), *Begonia*, *Money plant* (*Epipremnum aureum*), *Oxalis*.

Final Answer: Heliophytes need full sun (e.g. sunflower); sciophytes need shade (e.g. fern).

♥ **Real-world tie-in**

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION *: Kavya Singh, M.Sc Botany, Delhi University*

Strategic angle. Greek prefixes again: *helio-* = sun; *scio-* = shade. Pair with one common Indian plant each for full marks.

Step 1. Helio = open-ground sun-lover (sunflower, *Tridax*).

Step 2. Scio = shade-dweller (ferns, money plant indoors).

> **Final Answer:** Heliophyte = sun plant; sciophyte = shade plant.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.
Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.44 Why do submerged plants receive weaker illumination than exposed floating plants in a lake?

SOLUTION

Concept used. Sunlight entering water is attenuated by two processes: **absorption** by water molecules and dissolved matter, and **scattering** by suspended particles. Both increase exponentially with depth, following the Beer–Lambert law $I(z) = I_0\, e^{-kz}$, where I_0 is surface intensity, z is depth and k is the extinction coefficient. Different wavelengths are absorbed at different depths: red light disappears in the first 5–10 m, blue penetrates deepest.

Step 1. Floating plants (*Eichhornia*, *Nymphaea* leaves, *Pistia*) sit at the surface and receive the full unattenuated sunlight.

Step 2. Submerged plants (*Hydrilla*, *Vallisneria*, *Ceratophyllum*) sit metres below; the water column above absorbs and scatters most of the incident PAR.

Step 3. Hence the same lake delivers high light at the surface (for floaters) and progressively weaker light at depth (for submerged plants). The submerged forms compensate with more chlorophyll per cell and thin, finely-divided leaves to maximise surface area.

> **Final Answer:** Light is absorbed and scattered as it passes through water, so the submerged plants receive only a fraction of the surface intensity.

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION *: Diya Verma, M.Sc Botany, Delhi University*

Picture-first. Sunlight is bright at the lake's surface and dimmer underwater. The deeper you go, the dimmer it gets, because the water column has absorbed and scattered photons along the way.

Step 1. Surface light I_0 is full strength.

Step 2. At depth z, $I(z) = I_0 e^{-kz}$.

Step 3. Floating leaves see I_0; submerged leaves see $I(z) \ll I_0$.

> **Final Answer:** Water absorbs and scatters light, reducing what submerged plants receive.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.

Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.45 **In a sea shore, the benthic animals live in sandy, muddy and rocky substrata and accordingly developed the following adaptations.**

(a) Burrowing

(b) Building cubes

(c) Holdfasts / peduncle

Find the suitable substratum against each adaptation.

SOLUTION

Concept used. Benthos are the animals and plants living on or in the sea bottom. The substratum (sand, mud, rock) constrains their morphology: soft loose substrata favour burrowers; soft cohesive substrata favour tube-builders; hard substrata favour attachment structures.

Step 1. Match adaptation → substratum:

- (a) *Burrowing* — possible only in loose, penetrable material. ⇒ **Sandy** substratum. Examples: clams, sand crabs, polychaetes.
- (b) *Building tubes* (the question's "cubes" should read "tubes") — soft cohesive mud holds tube-shape best. ⇒ **Muddy** substratum. Examples: tubicolous polychaetes (*Chaetopterus*), some crustaceans.
- (c) *Holdfasts/peduncles* — anchor the animal or plant to a hard surface against wave drag. ⇒ **Rocky** substratum. Examples: barnacles' cement, mussels' byssal threads, kelp holdfasts.

> **Final Answer:** (a) Sandy → burrowing; (b) Muddy → tube building; (c) Rocky → holdfasts/peduncles.

☞ **Strategic shortcut**

Where the question hands you a sign signature (+, − etc.) or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION *: Vivaan Kapoor, M.Sc Zoology, Banaras Hindu University*

Strategic angle. Two of three matches are obvious. "Burrowing" needs material you can dig into → sand. "Holdfasts" need something to clamp → rock. The remaining one (tubes) goes with mud.

Step 1. Burrow → sand.

Step 2. Tube → mud.

Step 3. Holdfast/peduncle → rock.

> **Final Answer:** Sand–burrow, Mud–tube, Rock–holdfast.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly

draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.46 Categorise the following plants into hydrophytes, halophytes, mesophytes and xerophytes. Give reasons for your answers.
(a) Salvinia
(b) Opuntia
(c) Rhizophora
(d) Mangifera

SOLUTION

Concept used. Plants are classified by their water-relations into four groups: **hydrophytes** (live in or on water, adaptations for buoyancy and gas exchange under water), **xerophytes** (live in dry habitats, adaptations to conserve water — thick cuticle, succulence, spines), **halophytes** (live in saline soils/water, adaptations to handle salt — salt glands, succulent leaves, pneumatophores), **mesophytes** (live in normal moist soil with average rainfall).

Step 1. Classify each plant.

- (a) *Salvinia*: free-floating fern of ponds and ditches. ⇒ **Hydrophyte**. Reason: its leaves float on water; lower surface absorbs water; aerenchyma provides buoyancy.
- (b) *Opuntia* (prickly pear cactus): grows in arid scrub. ⇒ **Xerophyte**. Reason: leaves reduced to spines (low transpiring surface); thick cuticle; succulent stem stores water; CAM photosynthesis.
- (c) *Rhizophora*: a true mangrove of tidal coasts. ⇒ **Halophyte**. Reason: tolerates seawater salinity via salt-secreting leaves; pneumatophores for gas exchange in waterlogged soil; viviparous seedlings.
- (d) *Mangifera* (mango): a typical tropical tree in well-drained moist soil. ⇒ **Mesophyte**. Reason: moderate cuticle, broad mesophyllic leaves, no special water- or salt-coping structures.

Final Answer: Salvinia = hydrophyte; Opuntia = xerophyte; Rhizophora = halophyte; Mangifera = mesophyte.

☞ **Quick recall**
Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response

strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION *: Tara Nair, M.Sc Botany, Delhi University*

Strategic angle. Match the plant to its habitat first; the ecological category follows.

Step 1. Floating on water → hydrophyte (Salvinia).

Step 2. Desert, succulent + spiny → xerophyte (Opuntia).

Step 3. Tidal mangrove forest → halophyte (Rhizophora).

Step 4. Garden orchard, average soil → mesophyte (Mangifera).

Final Answer: Salvinia–hydro; Opuntia–xero; Rhizophora–halo; Mangifera–meso.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.
Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Q 11.47 **In a pond, we see plants which are free-floating; rooted-submerged; rooted emergent; rooted with floating leaves. Write the type of plants against each of them. (a) Hydrilla (b) Typha (c) Nymphaea (d) Lemna (e) Vallisneria**

SOLUTION

Concept used. Pond hydrophytes are sub-classified by their rooting and leaf position: *free-floating* (no roots in soil, floats on water surface), *rooted-submerged* (rooted in pond bed, entire plant under water), *rooted-emergent* (rooted in pond bed, shoot rises above water), *rooted with floating leaves* (rooted in bed, long petiole, leaves float on surface).

Step 1. Classify each species using its habit.

- (a) *Hydrilla* ⇒ rooted-submerged (entire plant under water, rooted in bed).
- (b) *Typha* (cattail) ⇒ rooted-emergent (roots in pond mud, leaves and inflorescence well above water).
- (c) *Nymphaea* (water lily) ⇒ rooted with floating leaves (rhizome in mud, leaves float on surface on long petioles).
- (d) *Lemna* (duckweed) ⇒ free-floating (tiny rootlets dangle, not anchored).
- (e) *Vallisneria* ⇒ rooted-submerged (ribbon-like leaves under water; rooted in bed).

> **Final Answer:** Hydrilla — rooted submerged; Typha — rooted emergent; Nymphaea — rooted with floating leaves; Lemna — free floating; Vallisneria — rooted submerged.

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION : *Ishaan Joshi, M.Sc Botany, Delhi University*

Strategic angle. For each species answer two yes/no questions: is it rooted in mud? Are its leaves above water, on the surface, or submerged?

Step 1. Hydrilla — rooted, leaves submerged.

Step 2. Typha — rooted, shoot emergent.

Step 3. Nymphaea — rooted, leaves floating.

Step 4. Lemna — unrooted (free floating).

Step 5. Vallisneria — rooted, leaves submerged.

> **Final Answer:** See main solution.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.48 The density of a population in a habitat per unit area is measured in different units. Write the unit of measurement against the following:
(a) Bacteria (b) Banyan (c) Deer (d) Fish

SOLUTION

Concept used. Population density is the count of individuals per chosen unit of habitat. The *unit* chosen depends on the species' body size and the medium: microscopic organisms are measured per ml or per cm^2; small plants per m^2; large trees per hectare; mobile animals per km^2 for terrestrial, per litre or m^3 for aquatic.

Step 1. Match species → unit.

- (a) *Bacteria* are microscopic and counted in cultures or environmental samples. Unit: **cells per ml** (or per cm^2 of surface).
- (b) *Banyan* is a very large tree; only a few fit per hectare. Unit: **trees per hectare**.
- (c) *Deer* are large mobile mammals roaming forests; the natural unit is **deer per km^2**.
- (d) *Fish* live in three-dimensional water; the unit is **fish per litre** (small species) or *fish per m^3*.

Final Answer: Bacteria — cells/ml; Banyan — trees/ha; Deer — animals/km^2; Fish — fish/litre.

♥ **Real-world tie-in**

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION *: Sanya Rao, M.Sc Microbiology, JNU*

Strategic angle. Scale the unit to the organism: tiny = ml-scale; small plant = m^2; tree = ha; mobile mammal = km^2; aquatic small = litre.

Step 1. Bacteria → /ml.

Step 2. Banyan → /ha.

Step 3. Deer → /km^2.

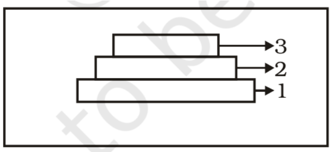
Step 4. Fish → /litre.

Final Answer: Units chosen above match species size.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.

Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.49 **Identify the age pyramid below and answer the questions.**



Age pyramid in SA Q10, NCERT Exemplar Class 12 Biology, Chapter 13.

(a) Label the three tiers 1, 2, 3 given in the above age pyramid.
(b) What type of population growth is represented by the above age pyramid?

SOLUTION

Concept used. An age pyramid stacks the three age classes from bottom (pre-reproductive) to middle (reproductive) to top (post-reproductive). The widths of the three bands indicate cohort sizes. A pyramid with the broadest bar on the bottom and the narrowest bar on top is a *triangular* (expanding) pyramid — characteristic of a **growing population**: lots of young about to enter the reproductive phase.

Step 1. Label the tiers from bottom upward as the question's arrows indicate:

- Tier 1 (bottom, the widest bar) = **pre-reproductive** (young) class.
- Tier 2 (middle) = **reproductive** class.
- Tier 3 (top, the narrowest bar) = **post-reproductive** (old) class.

Step 2. Diagnose the shape: pre-reproductive cohort > reproductive cohort > post-reproductive cohort ⇒ triangular (expanding) pyramid.

Step 3. Predict the population status: the broad young cohort will mature into the reproductive class and produce many more offspring than the small post-reproductive cohort is removing through mortality. The population will therefore **increase**.

> **Final Answer:** (a) 1 = Pre-reproductive, 2 = Reproductive, 3 = Post-reproductive. (b) Expanding (growing) population.

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION *: Krishna Iyer, M.Sc Botany, Delhi University*

Picture-first. Three pyramid shapes occur in the textbook: triangular (broad base → growing), bell (equal bands → stable), inverted urn (broad top → declining). The Q10 figure matches the triangular shape — widest bar at the bottom.

Step 1. Tier 1 = pre-reproductive; Tier 2 = reproductive; Tier 3 = post-reproductive.

Step 2. Broad base + narrow top ⇒ triangular pyramid ⇒ expanding (growing) population.

> **Final Answer:** Pre-/reproductive/post-reproductive bottom-to-top; expanding (growing) population.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.50 **In an association of two animal species, one is a termite which feeds on wood and the other is a protozoan Trichonympha present in the gut of the termite.**

What type of association they establish?

SOLUTION

Concept used. **Trichonympha** is a flagellate protozoan that lives inside the hindgut of wood-eating termites. The termite swallows wood but cannot digest cellulose itself; *Trichonympha* secretes **cellulase** enzymes that break cellulose into simple sugars. Both the termite (gets digestible food) and the protozoan (gets a stable warm habitat and a steady cellulose supply) benefit. This is a textbook case of **mutualism** — sign $(+, +)$.

Step 1. Identify benefit to each partner.

- Termite: cellulose in chewed wood is digested into glucose by the protozoan's enzymes; the termite absorbs the sugars.
- Trichonympha: gets a stable warm anaerobic habitat and a continuous supply of cellulose substrate.

Step 2. Both sides gain $\Rightarrow$ sign signature $(+, +)$ $\Rightarrow$ mutualism.

Step 3. The relationship is also **obligate** on both sides: the termite starves without *Trichonympha*; the protozoan cannot live outside the termite gut.

> **Final Answer:** Mutualism — obligate, both partners benefit.

☞ **Strategic shortcut**

Where the question hands you a sign signature $(+, -$ etc.$)$ or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION : *Aanya Sharma, M.Sc Microbiology, JNU*

Quick reading. "Both gain" + "neither can do without the other" = obligate mutualism. Trichonympha–termite is the canonical gut-symbiosis example.

Step 1. Termite supplies wood; protozoan supplies cellulase.

Step 2. Result: glucose for both.

Step 3. Sign $(+, +) \Rightarrow$ mutualism.

> **Final Answer:** Obligate mutualism.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.

Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.51 Lianas are vascular plants rooted in the ground and maintain erectness of their stem by making use of other trees for support. They do not maintain direct relation with those trees. Discuss the type of association the lianas have with the trees.

SOLUTION

Concept used. **Lianas** are woody climbers (vascular plants rooted in the soil) that twine around tall trees and use the tree trunks as scaffolding to reach the sunlit canopy. The liana gains access to high light; the supporting tree is not harmed provided the liana does not strangle or out-compete it. Where the support tree is genuinely unaffected, this is a textbook example of **commensalism** (sign $+/0$).

Step 1. Identify benefit/cost.

- Liana: gains height and access to canopy sunlight. Without the tree it would be limited to ground-level light.
- Host tree: the question stipulates no direct relation $\Rightarrow$ no measurable cost or benefit.

Step 2. Sign signature: $(+, 0) \Rightarrow$ commensalism.

Step 3. (Note: in nature heavy liana loads can damage trees, in which case the relationship turns to amensalism or even parasitism. The question's wording asks us to treat it as benign $\rightarrow$ commensalism.)

> **Final Answer:** Commensalism — the liana benefits, the supporting tree is unaffected.

☞ **Quick recall**

Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION : *Ananya Singh, M.Sc Botany, Delhi University*

Strategic angle. "Uses for support, no direct relation" is the textbook commensalism phrasing. The same logic explains epiphytes on mango branches and barnacles on whales.

Step 1. Liana = beneficiary.

Step 2. Tree = indifferent.

Step 3. Hence commensalism.

> **Final Answer:** Commensalism.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.

Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.52 **Give the scientific names of any two microorganisms inhabiting the human intestine.**

SOLUTION

Concept used. The human large intestine hosts a dense microbial community (**gut microbiota**, $\sim 10^{14}$ cells) in mutualistic relation with the host: they ferment otherwise indigestible fibre into short-chain fatty acids, synthesise vitamins K and B_{12}, and exclude pathogens. Two widely recognised gut residents are *Escherichia coli* (a facultative anaerobe in the colon) and *Lactobacillus acidophilus* (a fermenter that acidifies the gut and inhibits pathogens). *Bifidobacterium bifidum* and *Bacteroides fragilis* are equally acceptable.

Step 1. Pick two named gut bacteria.

Step 2. Italicise the binomials (genus + species).

> **Final Answer:** *Escherichia coli* and *Lactobacillus acidophilus*.

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION *: Pooja Patel, M.Sc Biotechnology, AIIMS Delhi*

Quick reading. Two names with proper binomial italicisation get full marks. Standard pair: *E. coli* and *Lactobacillus acidophilus*.

Step 1. Bacterium 1: *Escherichia coli*.

Step 2. Bacterium 2: *Lactobacillus acidophilus*.

> **Final Answer:** *E. coli*, *L. acidophilus*.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.

Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.53 What is a tree line?

SOLUTION

Concept used. The **tree line** (or timber line) is the upper altitudinal (or northern/southern latitudinal) limit beyond which trees can no longer grow. Above the tree line, only shrubs, herbs, mosses and lichens persist — a transition called the alpine or arctic zone. The limit is set by low temperatures (growing-season length too short for woody tissue to mature), strong winds, snow cover and a short frost-free season.

Step 1. Define: the boundary in altitude/latitude past which trees cannot establish or survive.

Step 2. Identify the cause: combination of low temperature, short growing season, wind, ice abrasion.

Step 3. Indian example: in the Himalayas, the tree line lies approximately at $3500–4000$ m; above it spreads the alpine meadow with only shrubs (e.g. *Rhododendron*).

> **Final Answer:** The upper altitudinal/latitudinal boundary above which trees cannot grow, set chiefly by cold and short growing season.

♥ Real-world tie-in

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION : *Rahul Chatterjee, M.Sc Botany, Delhi University*

Strategic angle. "Boundary above which X cannot grow" defines any X-line: tree line, snow line, frost line. Each is set by a single dominant climatic limit.

Step 1. Tree line = upper limit of tree growth.

Step 2. Cause: cold + short growing season.

> **Final Answer:** Upper altitudinal limit beyond which trees cannot survive.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.54 **Define 'zero population growth rate'. Draw an age pyramid for the same.**

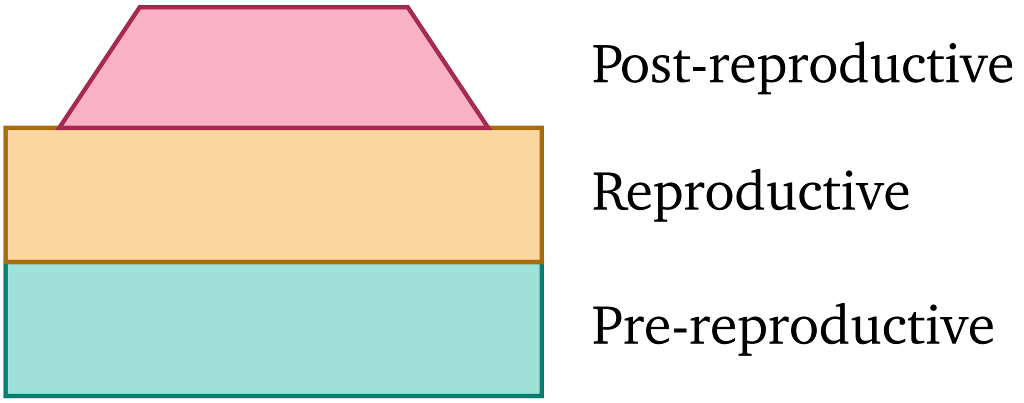
SOLUTION

Concept used. A population has **zero population growth rate** (ZPG) when births + immigration exactly equal deaths + emigration, so the population size stays constant over time. In the simplest closed-population case, this reduces to natality = mortality. The age pyramid that represents ZPG is roughly *bell-shaped*: pre-reproductive and reproductive cohorts of about equal size, with a slightly tapering post-reproductive top.

Step 1. Definition. ZPG: $\frac{dN}{dt} = 0$, equivalent to $b = d$ (per-capita birth = per-capita death). Net effect: the population neither grows nor shrinks.

Step 2. Population it describes: many developed countries with approximately equal birth and death rates and low net migration.

Step 3. Draw the pyramid.



Bell-shaped age pyramid (ZPG)

Final Answer: ZPG: births = deaths so $dN/dt = 0$; the age pyramid is bell-shaped (equal pre-reproductive and reproductive bands).

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION : *Meera Bhat, M.Sc Zoology, Banaras Hindu University*

Strategic angle. Two ingredients: a one-sentence definition ($b = d$) and a bell-shaped pyramid sketch. Both are needed for full marks.

Step 1. Quantitative definition: $b = d \Rightarrow dN/dt = 0$.

Step 2. Qualitative shape: bell — equal middle bands, tapered top.

Final Answer: Stable population, bell pyramid.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.
Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Q 11.55 **List any four characters that are employed in human population census.**

SOLUTION

Concept used. A national **census** is a periodic enumeration of a country's population. Beyond the headcount, several demographic attributes are recorded to plan policy. The Indian decennial census records dozens of variables; any four of the following count for this question.

Step 1. List four characters commonly recorded:

- **Age structure** (age distribution into pre-reproductive, reproductive, post-reproductive).
- **Sex ratio** (number of females per 1000 males).
- **Natality** (birth rate) and **mortality** (death rate).
- **Literacy rate**.
- Occupation/employment.
- Religion, language, marital status.

Step 2. Any four are acceptable.

Final Answer: Any four of: age structure, sex ratio, natality, mortality, literacy, occupation.

☞ **Strategic shortcut**

Where the question hands you a sign signature (+, – etc.) or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION : *Aarav Verma, M.Sc Microbiology, JNU*

Quick reading. Pick four of the obvious demographic variables; any four are fine.

Step 1. Age + sex + birth rate + death rate is a safe pick.

Final Answer: Age, sex ratio, natality, mortality.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Q 11.56 Give one example for each of the following types.

(a) Migratory animal

(b) Camouflaged animal

(c) Predator animal

(d) Biological control agent

(e) Phytophagous animal

(f) Chemical defense agent

SOLUTION

Concept used. Each category names a distinct ecological role; one named example per category is enough.

Step 1. (a) Migratory animal: *Siberian crane* (*Grus leucogeranus*) — winters in India, breeds in Siberia. Alternative: Arctic tern, wildebeest.

Step 2. (b) Camouflaged animal: *stick insect* (*Phasma*) or the *leaf insect* (*Phyllium*) — body mimics twigs/ leaves. Alternative: chameleon, ptarmigan.

Step 3. (c) Predator animal: *tiger* (*Panthera tigris*). Alternative: lion, hawk, frog.

Step 4. (d) Biological control agent: *Ladybird beetle* (*Coccinella*) — preys on aphids to protect crops. Alternative: *Trichogramma*, *Bacillus thuringiensis*.

Step 5. (e) Phytophagous animal: *grasshopper* (*Schistocerca gregaria*) or aphid; feeds entirely on plants.

Step 6. (f) Chemical defense agent: *Monarch butterfly* (*Danaus plexippus*) — its larva sequesters cardiac glycosides from milkweed; *Calotropis* latex itself is a plant chemical defense.

> **Final Answer:** (a) Siberian crane (b) Stick insect (c) Tiger (d) Ladybird beetle (e) Grasshopper (f) Monarch butterfly.

☞ Quick recall

Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION : *Yash Banerjee, M.Sc Zoology, Banaras Hindu University*

Strategic angle. For each category, write the most iconic example you remember — that minimises the risk of a debatable answer.

Step 1. Use the canonical example list above.

> **Final Answer:** See main solution.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.
Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.
Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising

the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.

Q 11.57 **Fill in the blanks.**

Species A	Species B	Type of Interaction	Example
+	−	________	________
+	+	________	________
+	_____	**Commensalism**	________

SOLUTION

Concept used. Use the sign table for interspecific interactions (built in MCQ Q17). Fill each blank by reading the sign pair.

Step 1. Row 1: $(+, -)$. Species A gains; species B suffers. That is **predation** or **parasitism**. Example: *Tiger* eating *deer* (predation); *Plasmodium* in human blood (parasitism).

Step 2. Row 2: $(+, +)$. Both gain. That is **mutualism**. Example: lichen (fungus + alga), or pollinator bee + flower.

Step 3. Row 3: $(+, ?)$ labelled *commensalism*. The commensalism sign is $(+, 0)$, so the missing sign is **0**. Example: cattle egret + cattle.

Step 4. Completed table:

Species A	Species B	Type of interaction	Example
+	−	Predation/Parasitism	Tiger–Deer (predation)
+	+	Mutualism	Lichen (fungus + alga)
+	0	Commensalism	Cattle egret + cattle

Final Answer: See completed table above.

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION : *Sneha Desai, M.Sc Botany, Delhi University*

Strategic angle. Each row is a sign pair → a name → a canonical example. Just translate from the sign table you built in Q17.

Step 1. $(+,-)$: predation or parasitism — tiger eats deer.

Step 2. $(+,+)$: mutualism — lichen.

Step 3. $(+,0)$: commensalism — cattle egret + cattle.

> **Final Answer:** Predation, Mutualism, Commensalism with examples above.

Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors → organismic responses" and "population attributes → growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.

Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.58 **Observe the set of 4 figures A, B, C and D and answer the following questions.**

(i) Which one of the figures shows mutualism?

(ii) What kind of association is shown in D?

(iii) Name the organisms and the association in C.

(iv) What role is the insect performing in B?

Fig. (A)

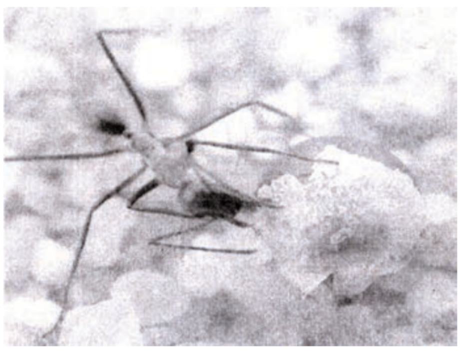


Fig. (B)

Fig. (A) Male long-tailed blue on orchid; Fig. (B) Insect on flower. NCERT Exemplar Class 12 Biology, Chapter 13.

Fig. (C)

Fig. (D)

Fig. (C) Cattle with cattle egret; Fig. (D) Cheetah hunting in tall grass. NCERT Exemplar Class 12 Biology, Chapter 13.

SOLUTION

Concept used. Figure A shows an orchid in bloom with a male long-tailed blue butterfly — an example of an orchid flower mimicking a female butterfly so the male attempts pseudo-copulation and pollinates the flower (deceit pollination, a form of one-sided gain favouring the plant). Figure B shows an insect (bee) actively collecting pollen and nectar from a flower — classical pollinator mutualism. Figure C shows cattle egrets sitting on grazing cattle — commensalism. Figure D shows a predator (cheetah/wild cat) stalking prey — predation.

Step 1. (i) Mutualism: the bee–flower pair in **Fig. B** — both partners benefit (bee gets food, flower gets cross- pollination).

Step 2. (ii) Fig. D shows **predation** — a predator (cheetah/cat) stalking prey hidden in tall grass.

Step 3. (iii) Fig. C shows **cattle** (*Bos indicus*) with the **cattle egret** (*Bubulcus ibis*). The association is **commensalism**: the egret gains (feeds on insects flushed by the cattle), and the cattle are unaffected.

Step 4. (iv) The insect in Fig. B is acting as a **pollinator** — it collects nectar/pollen and transfers pollen between flowers, enabling cross-pollination of the angiosperm.

Final Answer: (i) B; (ii) Predation; (iii) Cattle + cattle egret, commensalism; (iv) Pollinator.

♥ Real-world tie-in

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION : *Vivaan Mehta, M.Sc Zoology, Banaras Hindu University*

Picture-first. Map each figure to a sign-table category. A = pseudo-copulation (orchid mimicry, deceit). B = insect pollinator (mutualism). C = cattle egret on cattle (commensalism). D = cat stalking prey (predation).

Step 1. Mutualism is the only $(+,+)$ candidate → B.

Step 2. D is hunting → predation.

Step 3. C cattle + egret → commensalism.

Step 4. B insect → pollinator.

> **Final Answer:** See main solution.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.

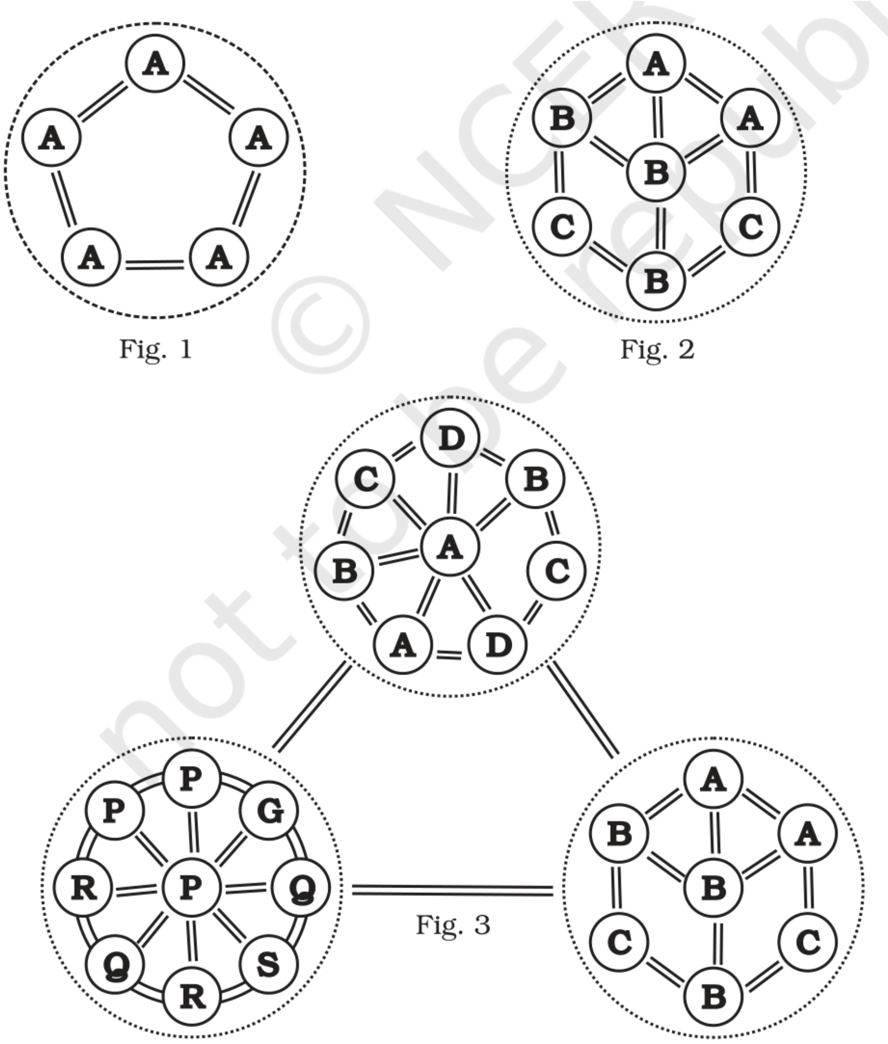
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.

Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.

Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

Long Answer Type Questions

Q 11.59 **Comment on the following figures: 1, 2 and 3 (A, B, C, D, G, P, Q, R, S are species).**



Figs. 1, 2 and 3 from NCERT Exemplar Class 12 Biology Chapter 13 — species-interaction diagrams.

SOLUTION

Concept used. Each circle in the figure represents a **community** (the dashed/dotted boundary). The letters inside each circle are **species**; lines between species denote ecological connections (feeding, competition, mutualism). The arrangement of circles encodes the spatial relationship of the communities — a single isolated community in Fig. 1, two adjacent communities sharing an **ecotone** in Fig. 2, and three adjacent communities meeting at multiple ecotones in Fig. 3.

Step 1. **Fig. 1.** A single community containing only one species (*A*) repeated several times. This is a **monospecific community** — low species diversity, the kind you see in monoculture plantations (e.g. a teak plantation, or a wheat field).

Step 2. **Fig. 2.** Two distinct communities placed side-by-side: one made of species *A* and a second of species *B* and *C*. The narrow overlap shows three species mixing — that overlap region is the **ecotone**. Ecotones display the **edge effect**: greater diversity than either community alone.

Step 3. **Fig. 3.** Three communities arranged around a central community.

- *Community 1*: species *A, B, C* (similar to the upper part of Fig. 2).
- *Community 2*: species *P, Q, R, S* (a richer assemblage).
- *Community 3*: species *A, B, C, D* (one more than community 1; broader diversity).

All three meet at a central ecotone where species from multiple communities mix. This represents a complex landscape mosaic — for example a forest patch (community 2), a grassland (community 3) and a wetland (community 1) meeting at a single junction.

Step 4. **Take-away.** The figures move from monoculture (Fig. 1, lowest diversity) to a two-community ecotone (Fig. 2) to a three-community mosaic (Fig. 3, highest diversity and edge effect). The pattern shows how community boundaries generate biological richness.

> **Final Answer:** Fig. 1 — single (monospecific) community; Fig. 2 — two communities sharing one ecotone; Fig. 3 — three communities meeting at a central ecotone, demonstrating maximum edge effect.

EXPERT'S SOLUTION *: Karan Banerjee, Ph.D Molecular Biology, NCBS Bangalore*

Structural observation. The three figures form a sequence: (1) a community with no neighbours, (2) two communities sharing one edge, (3) three communities sharing edges with each other. Each extra neighbour adds an ecotone, and each ecotone adds diversity.

Step 1. **Fig. 1.** A single dashed circle with species *A* repeated. This is a single community of one species — a monoculture. Diversity is the lowest possible: just one taxon. Real-world analogue: *Eucalyptus* plantation, paddy field, or naturally low-diversity systems like deep cave pools.

Step 2. **Fig. 2.** Two circles touching, one labelled with *A* repeated and the other with *B* and *C*. The overlap zone contains representatives of *A*, *B* and *C* simultaneously — that overlap is an ecotone. Ecotones have:

- Species from community 1.
- Species from community 2.
- Edge specialists (sometimes called "ecotone species") that exploit conditions intermediate between the two communities.

Net effect: $S_{\text{ecotone}} \geq \max(S_1, S_2)$, where S is the species richness.

Step 3. **Fig. 3.** Three circles arranged as a triangle, each sharing an edge with the other two. The central junction is a multi-way ecotone: species from communities 1, 2 and 3 all meet here. Compared with Fig. 2, the diversity in this ecotone is even higher because three source communities contribute species.

Step 4. **Generalisation.** As landscapes become more heterogeneous — more communities meeting at more boundaries — both alpha diversity (within-community) and gamma diversity (regional total) increase. This is why conservation biologists value landscape mosaics over single large homogeneous patches.

Step 5. **Cross-reference.** Compare with the definition of *ecotone* (MCQ Q2) and the edge effect mentioned in the chapter.

Why this matters. The figures encode a core ecological idea: *community boundaries create biological richness*. The edge of a forest, a wetland margin or a mangrove all show higher diversity than the interiors. Mosaic landscapes are productive for the same reason.

> **Final Answer:** Fig. 1 monospecific community; Fig. 2 two communities sharing an ecotone; Fig. 3 three communities sharing a multi-way ecotone — diversity rises with each added boundary.

♥ Edge effect in conservation

The Western Ghats–Deccan Plateau ecotone is a global biodiversity hotspot precisely because forest, grassland and rocky habitats meet there. Identifying and protecting ecotones is a high-leverage conservation strategy.

Q 11.60 An individual and a population has certain characteristics. Name these attributes with definitions.

SOLUTION

Concept used. The textbook draws a sharp distinction between attributes of an **individual** (properties of a single organism) and attributes of a **population** (properties of the collective that no individual possesses). The latter is the bedrock of population ecology.

Step 1. **Attributes of an individual.**

- Born and dies once in its lifetime.
- Has a definite age, sex, body size and physiological state at any moment.
- Has a fixed birth date and a fixed (future) date of death.

- Other measurable individual traits: rate of growth, fecundity, behaviour, genotype.

An individual cannot have a "birth *rate*" or a "density" — those are collective concepts.

Step 2. **Attributes of a population.** (These are the attributes **birth rate**, **death rate**, **sex ratio**, **age distribution** and **population density** discussed in the chapter.)

- **Birth rate** (natality): number of new individuals added per existing individual per unit time. e.g. "4 births per individual per year" for a lotus pond population.
- **Death rate** (mortality): number of deaths per existing individual per unit time.
- **Sex ratio**: relative proportion of males to females (often reported as females per 1000 males).
- **Age distribution**: number of individuals in each age class (pre-, reproductive, post- reproductive); displayed as an age pyramid.
- **Population density**: number of individuals per unit area or volume of habitat. Symbolised N. Density can also be measured indirectly via percent cover, biomass, or pug-marks / scats (MCQ Q13).
- **Population size** (N): the total number of individuals.

Step 3. **Mathematical link to growth.** Population density at the next time step is $N_{t+1} = N_t + B + I - D - E$, with B, I, D, E the four flows (see MCQ Q14). All four are population-level attributes; none belongs to a single individual.

> **Final Answer:** Individual: born, dies, has age, sex, size. Population: birth rate, death rate, sex ratio, age distribution, density.

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION *: Priya Reddy, M.Sc Zoology, Banaras Hindu University*

Strategic angle. Build a two-column comparison: one column for individual traits (singular, observable on one organism), one for population traits (rates, ratios, distributions — observable only on the group).

Step 1. **Individual attributes.**

- Birth and death — one each in a lifetime.
- Age, sex, body mass at any moment.
- Genotype, physiology, behaviour, fecundity.

Each is a single value, not a rate.

Step 2. Population attributes — five core ones.

- *Birth rate (natality).* Number of births per individual per unit time. Example: "In a pond of 20 lotus plants there were 8 new individuals in the last year" $\Rightarrow$ birth rate $= 8/20 = 0.4$ per lotus per year.
- *Death rate (mortality).* Deaths per individual per unit time.
- *Sex ratio.* Proportion of males vs females, or females per 1000 males.
- *Age distribution.* Numbers in pre-/ reproductive/post-reproductive classes, drawn as an age pyramid.
- *Population density.* Number of individuals per unit area or volume.

Step 3. Why distinct. A single tiger has neither a birth rate nor a sex ratio nor an age distribution. These are *emergent* attributes of the group.

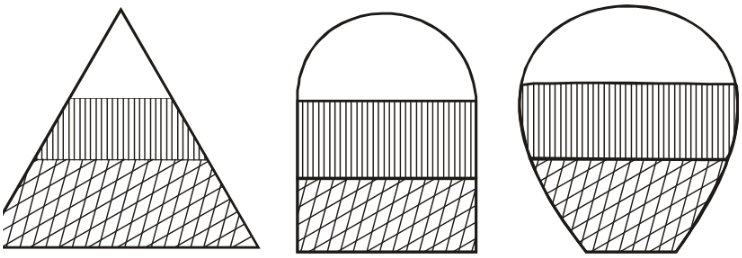
Step 4. Worked example. A village school with 300 students has age distribution (Class 1 to 12), sex ratio (boys:girls), birth rate (new admissions per existing student per year). Individual students have age, sex and grade. The two attribute sets do not overlap.

Step 5. Use in the chapter. The population attributes feed into the exponential ($dN/dt = rN$) and logistic ($dN/dt = rN(K - N)/K$) growth models examined in LA Q4.

Why this matters. Whenever the chapter (or NEET) talks about "the population grew at $r = 0.02$" or "the age pyramid is expanding", it is invoking population-level attributes that simply do not exist for any one organism.

Final Answer: Individual: birth, death, age, sex, body characters. Population: birth rate, death rate, sex ratio, age distribution, density.

Q 11.61 The following diagrams are the age pyramids of different populations. Comment on the status of these populations.



Three age pyramids A, B, C; NCERT Exemplar Class 12 Biology, Chapter 13.

SOLUTION

Concept used. An **age pyramid** stacks the three age classes — pre-reproductive (bottom), reproductive (middle), post- reproductive (top) — with the width of each band proportional to the cohort size at the census. The shape predicts future population trajectory. Three canonical shapes are recognised: triangular (growing), bell (stable), inverted urn (declining).

Step 1. **Pyramid A — triangular.** Broad base (large pre- reproductive cohort), narrower middle, narrowest top. This is an **expanding population**: when the broad young cohort matures into the reproductive class, it will produce many offspring, so the population will keep growing. Modern analogues: India's age structure circa 2001, much of sub-Saharan Africa today.

Step 2. **Pyramid B — bell-shaped.** Equal pre-reproductive and reproductive bands, slightly tapering post-reproductive top. This is a **stable population**: each reproductive cohort is being replaced by an equally-sized young cohort. Birth rate $\approx$ death rate. Many developed European countries (early-2000s Germany, France).

Step 3. **Pyramid C — inverted urn.** Narrow base, broad reproductive middle, broad top. This is a **declining population**: too few young to replace the reproductive cohort when it ages out. Japan and Italy today show this pattern.

Step 4. **Take-away.** The base-to-top width gradient encodes the population's future:

- Base wider than top $\rightarrow$ growth.
- Equal $\rightarrow$ stability.
- Top wider than base $\rightarrow$ decline.

Final Answer: A — expanding (triangular); B — stable (bell); C — declining (inverted urn).

EXPERT'S SOLUTION : *Ananya Joshi, M.Sc Botany, Delhi University*

Picture-first. Hold the three shapes in mind: a Christmas tree (triangular), a bell, and an upside-down vase. Each shape encodes a future trajectory because the shape of *today's* age distribution determines *tomorrow's* birth–death balance.

Step 1. Pyramid A. Christmas-tree shape: lots of children at the bottom, fewer adults, very few elderly. Mechanism: in the next $10–15$ years, that large young cohort enters reproduction. Births will outnumber deaths (the post- reproductive group is small). Population grows. This is the *expanding* pattern.

Step 2. Pyramid B. Bell shape: pre-reproductive and reproductive bars are about equal width; post-reproductive narrows. Mechanism: each generation produces roughly the same number of children as the parent generation. Births balance deaths. Population stays at constant size — the *stable* pattern.

Step 3. Pyramid C. Upside-down vase: narrow base, wide middle and top. Mechanism: too few children today to replace the reproductive cohort when it ages out. When the broad reproductive band shifts up to become post-reproductive, it will not be replaced by an equally broad band coming up from below. Births $<$ deaths. Population shrinks — the *declining* pattern.

Step 4. Quantify if asked. For each shape, also note the per-capita rate $r = b - d$. Pyramid A: $r > 0$. Pyramid B: $r \approx 0$. Pyramid C: $r < 0$.

Step 5. Real-world map.

- A: India (2001 census), Nigeria, Bangladesh today.
- B: Sweden, France in the late 1990s.
- C: Japan, Italy, Germany today.

Step 6. Why the same shape recurs. Because mortality and natality respond to economic and cultural conditions smoothly, age pyramids change shape over decades, not years. India's pyramid is slowly transitioning from A toward B.

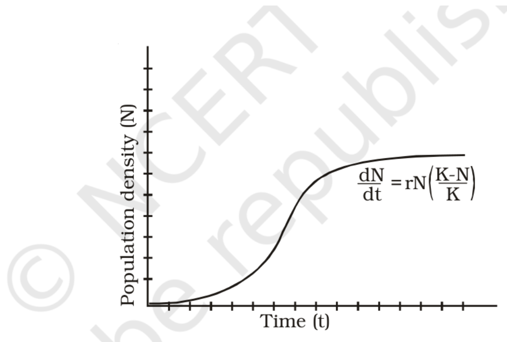
Why this matters. Age pyramids are the most compact forecasting tool in demography — a single diagram tells you whether to plan for new schools (A), maintain existing infrastructure (B), or prepare for an ageing-dependency burden (C).

Final Answer: A — expanding; B — stable; C — declining.

☞ **Sign of r from the pyramid**

Triangle $\rightarrow r > 0$; bell $\rightarrow r \approx 0$; inverted urn $\rightarrow r < 0$. Same shape, same sign, every time.

Q 11.62 **Comment on the growth curve given below.**



Logistic growth curve $dN/dt = rN\,(K - N)/K$*; NCERT Exemplar Class 12 Biology, Chapter 13.*

SOLUTION

Concept used. The S-shaped curve in the figure is the **logistic growth curve** described by the Verhulst–Pearl equation

$$\frac{dN}{dt} = rN \cdot \frac{K - N}{K},$$

where N is the population size at time t, r the intrinsic per-capita growth rate, and K the **carrying capacity** of the environment — the maximum population the resources can sustain indefinitely. Unlike exponential growth ($dN/dt = rN$, J-shape) which assumes unlimited resources, logistic growth includes a slowing term $(K - N)/K$ that dampens growth as N approaches K.

Step 1. Read the equation factor by factor.

- rN alone is the exponential term: at low N the population grows almost exponentially.
- $(K - N)/K$ is a unitless brake that decreases from 1 (when $N \ll K$) to 0 (when $N = K$). It represents environmental resistance — competition for food, space and other resources.

Step 2. Identify the four phases visible in the curve.

- *Lag phase* — low initial N; growth is slow because few breeders are present even though resources are abundant.
- *Log (exponential) phase* — once N rises, rN dominates and the curve is nearly exponential. The curve is steepest in this phase.
- *Slowing (deceleration) phase* — as N approaches K, the brake $(K - N)/K$ shrinks toward 0 and growth slows.
- *Stationary phase* — $N = K$, $dN/dt = 0$, births equal deaths. The curve flattens at K.

Step 3. When does this model apply? In every real environment with finite resources — which means essentially every natural population. Examples: yeast in a culture flask, *Paramoecium* in a test tube (see LA Q5), whitetail deer on an island, plankton blooms.

Step 4. Compare with exponential. The J-curve of $dN/dt = rN$ is unbounded; the S-curve of the logistic levels off at K. The logistic is therefore a more biologically realistic model.

Step 5. Inflection point. At $N = K/2$, growth rate dN/dt is maximum (you can verify by differentiating). After this point, the second derivative becomes negative and the curve bends toward K.

> **Final Answer:** The curve is the logistic (S-shaped) growth $dN/dt = rN(K - N)/K$ — exponential-like at low N, slowing as $N \to K$, and stationary at the carrying capacity K.

EXPERT'S SOLUTION *: Aditya Sharma, Ph.D Molecular Biology, NCBS Bangalore*

Structural observation. The S-curve is two equations glued together by a brake. At low N the brake $(K - N)/K \approx 1$, so $dN/dt \approx rN$ — exponential. At high N the brake $(K - N)/K \to 0$, so $dN/dt \to 0$ — stationary. The transition gives the S-shape.

Step 1. Set up the equation. The logistic equation is $dN/dt = rN \cdot (K - N)/K$. Two parameters: r (intrinsic rate, units of 1/time) and K (carrying capacity, units of individuals).

Step 2. Limiting behaviour.

- When $N \ll K$: $(K - N)/K \approx 1$, so $dN/dt \approx rN$. Exponential growth, J-shape.
- When $N = K$: $(K - N)/K = 0$, so $dN/dt = 0$. Growth halts. The curve plateaus.
- When $N > K$ (rare overshoot): $(K - N)/K < 0$, so $dN/dt < 0$. Population shrinks back toward K.

Step 3. Solve to find the inflection point. The growth rate $dN/dt = rN(K - N)/K$ is a parabola in N opening downward with zeros at $N = 0$ and $N = K$. The peak lies midway, at $N = K/2$.

- Compute the maximum growth:

$$\left.\frac{dN}{dt}\right|_{N=K/2} = r \cdot \frac{K}{2} \cdot \frac{K - K/2}{K} = r \cdot \frac{K}{2} \cdot \frac{1}{2} = \frac{rK}{4}.$$

- This is the steepest slope on the S-curve, the inflection point. After this, the curve concaves downward.

Step 4. Phase recap.

- Lag (low N, slow growth because few reproducers).
- Log (mid N, steepest growth).

- Slowing (approach to K, brake takes over).
- Stationary ($N = K$, $dN/dt = 0$).

Step 5. Where the model fits. Yeast cultures, bacteria in chemostats, sheep introduced to Tasmania, *Paramoecium* in flask cultures all show logistic-shaped trajectories. Real populations may overshoot K and crash — the logistic is a smoothing approximation.

Step 6. Equation insight. A useful identity for the plateau: at $N = K$, r has not changed — only the *realised* growth rate $rN(K - N)/K$ falls to zero because environmental resistance fully cancels r.

Why this matters. Conservation, fisheries and pest-control all use K as the policy target. Setting a yearly harvest at the maximum sustainable yield $= rK/4$ keeps the population at $K/2$ — the peak growth-rate point — without driving it to extinction.

Final Answer: Logistic (S-shaped) curve $dN/dt = rN(K - N)/K$ with lag, log, slowing and stationary phases.

☞ **J vs S**

J-shape: exponential, unlimited resources, no ceiling.
S-shape: logistic, limited resources, ceiling at K.

Q 11.63 A population of Paramoecium caudatum was grown in a culture medium. After 5 days the culture medium became overcrowded with Paramoecium and had depleted nutrients. What will happen to the population and what type of growth curve will the population attain? Draw the growth curve.

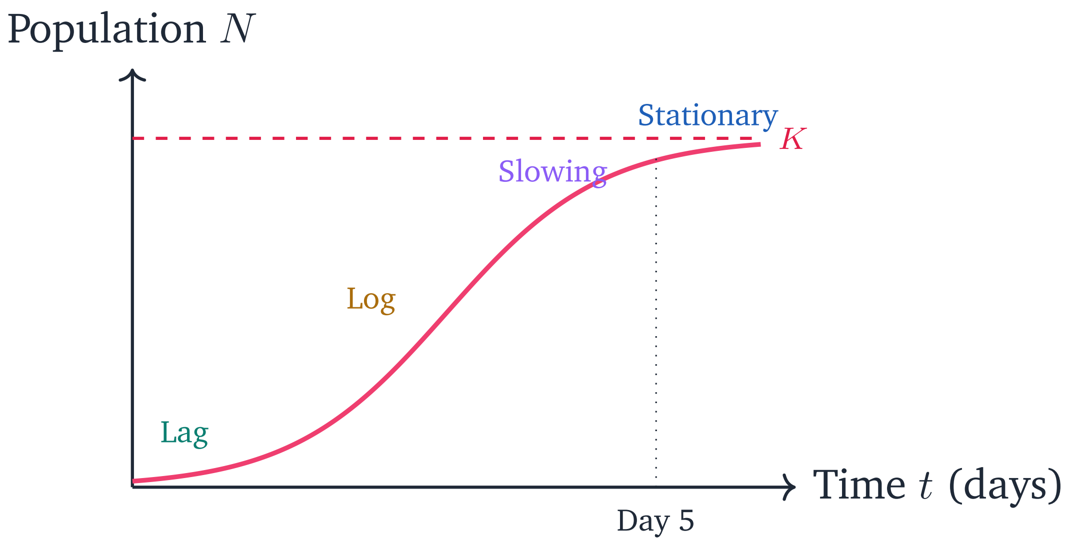
SOLUTION

Concept used. In a closed culture, *Paramoecium* growth is logistic (LA Q4). The early days show exponential rise; as nutrients deplete and metabolic waste accumulates, the death rate rises and the birth rate falls, so $dN/dt \to 0$ at the carrying capacity K. The population trajectory is therefore S-shaped.

Step 1. What happens after Day 5. Resources (food + space) are scarce; metabolic wastes are toxic. Birth rate drops, death rate rises. The growth rate dN/dt approaches zero.

Step 2. Type of curve. The whole experiment from inoculation to overcrowding traces a **sigmoid (S-shaped) logistic curve**.

Step 3. Sketch the curve.



Step 4. **Outcome.** The population plateaus at the carrying capacity K of the culture vessel. If nutrient depletion and waste build-up are severe, the population may even crash (a death phase). Removing waste and adding fresh medium (i.e. a chemostat) would let exponential growth resume.

> **Final Answer:** The population attains a sigmoid (S-shaped) logistic curve, plateauing at the culture's carrying capacity K.

☞ **Strategic shortcut**

Where the question hands you a sign signature $(+, -$ etc.$)$ or a prefix (steno-, eury-, helio-, scio-), decode that first — the correct option usually drops out immediately.

EXPERT'S SOLUTION *: Pranav Patel, M.Sc Biotechnology, AIIMS Delhi*

Strategic angle. A finite flask = finite resources = logistic growth. The S-curve is the only realistic answer; the J-curve would require an infinite chemostat.

Step 1. **Days 0–1: Lag phase.** The inoculum acclimatises; reproduction is slow because the few cells present can produce only a few daughters per division.

Step 2. **Days 1–3: Log phase.** The cells, now numerous and with abundant food, divide rapidly. $dN/dt \approx rN$ — nearly exponential. The Paramoecium count doubles every few hours.

Step 3. **Days 3–5: Slowing phase.** As N approaches K, the brake $(K - N)/K$ takes over. Cell division slows; some cells die from waste accumulation.

Step 4. **Day 5 onwards: Stationary phase.** Births equal deaths; net growth is zero. The plateau persists as long as nutrients remain.

Step 5. **Possible decline phase.** If the experiment is continued without fresh medium, nutrient exhaustion + waste toxicity overwhelms the population, and N begins to fall (a death/decline phase appears).

Step 6. **Sketch.** The curve mirrors Fig. LA Q4 — flat low, steep middle, flat top at K.

Step 7. **Cross-check.** This is the famous Gause experiment (1934) with *Paramoecium caudatum* that established the logistic model in animal populations.

Why this matters. The same logistic curve describes bacterial colonies, yeast fermentation, plankton blooms and even introduced mammal populations. The S-shape is one of the most universal patterns in population biology.

> **Final Answer:** S-shaped (sigmoid, logistic) curve plateauing at K after Day 5; the population stops growing and may eventually decline if waste accumulates further.

Q 11.64 **Discuss the various types of positive interactions between species.**

SOLUTION

Concept used. Positive interactions are those in which at least one partner gains and neither is harmed. From the sign-table (MCQ Q17), these are **mutualism** (+/+), **commensalism** (+/0) and the more permissive case of **proto-cooperation** (+/+ but optional). The chapter emphasises mutualism (the strongest positive interaction) and commensalism (the looser one-sided benefit).

Step 1. **Mutualism (+/+).** Both partners gain; often obligate (cannot live separately). Examples:

- **Lichen** = fungus + alga.
- **Mycorrhiza** = fungus + plant root.
- **Plant pollinator** mutualism — e.g. fig tree (*Ficus*) + fig wasp (*Blastophaga*). The wasp pollinates the fig flower; the fig provides a nursery for wasp larvae. Neither can complete its life cycle without the other.
- **Nitrogen fixation**: *Rhizobium* + legume root.
- **Termite + Trichonympha** (SA Q11).

Step 2. **Commensalism (+/0).** One species benefits; the other is unaffected.

- **Cattle egret** + cattle (insects flushed by grazing).
- **Orchid** (an epiphyte) on a mango branch — orchid gets sunny perch; mango unaffected.
- **Suckerfish** (*Remora*) attached to a shark — remora gets transport and food

scraps; shark unaffected.

- **Sea anemone on a hermit-crab shell** (in some pairings, only the anemone gains protection from the elevated perch; in others both gain — that's mutualism).

Step 3. Proto-cooperation. A facultative form of mutualism in which both partners gain but can live independently. Not always treated as a separate category; the textbook usually merges it with mutualism. Example: oxpecker birds feeding on ticks of zebra (both benefit; both can survive separately).

Step 4. Take-away. Positive interactions are central to community assembly: they let species colonise habitats they couldn't enter alone (lichen on bare rock), bridge nutrient gaps (mycorrhiza), and stabilise trophic chains (pollination).

> **Final Answer:** Mutualism (+/+, e.g. lichen, mycorrhiza, fig–fig wasp), Commensalism (+/0, e.g. cattle egret + cattle, orchid on mango) and Proto-cooperation (+/+, facultative; e.g. oxpecker + zebra).

EXPERT'S SOLUTION *: Ishita Singh, M.Sc Microbiology, JNU*

Strategic angle. Build a clean comparison table. Rows are the three positive interactions; columns are sign signature, whether obligate, and one canonical example each.

Step 1. Mutualism — $(+, +)$ obligate.

- Both gain; often neither can survive without the other.
- Examples: lichen (fungus + alga), mycorrhiza (fungus + root), *Rhizobium* + legume root, fig + fig wasp.
- *Mechanism.* One partner supplies what the other cannot make: alga supplies sugars to the fungus; fungus supplies water/minerals to the alga.

Step 2. Commensalism — $(+, 0)$.

- One gains; the other is indifferent.
- Examples: cattle egret + cattle, orchid + mango, remora + shark, barnacle + whale.
- *Mechanism.* The beneficiary exploits a resource (food, perch, transport, protection) that the indifferent partner inadvertently provides.

Step 3. Proto-cooperation — $(+, +)$ facultative.

- Both gain but neither is dependent.
- Example: oxpecker birds + zebra (bird eats ticks; zebra loses parasites). Hermit crab + sea anemone in some pairings.

Step 4. Why classification matters. Conservation actions often need to preserve *both* partners of a mutualism — saving only the fig tree without the fig wasp condemns both. Commensal pairs are robust because the indifferent partner doesn't need the beneficiary at all.

Step 5. Edge case. Same pair can shift category depending on context. Bee + flower in a normal year is mutualism; in a year of nectar shortage with no pollination return, the bee may visit without pollinating (commensal-leaning toward parasitism).

Step 6. Note. Some textbooks list only two positive interactions (mutualism, commensalism) and treat proto-cooperation as facultative mutualism. Both formulations are accepted answers.

Why this matters. Positive interactions explain many "impossible" ecological feats — bare rocks colonised by lichens, nitrogen-poor soils enriched by *Rhizobium*, dark forest floors fed by mycorrhizal networks. These interactions stabilise communities and accelerate succession.

> **Final Answer:** Mutualism (both gain, often obligate); Commensalism (one gains, one indifferent); Proto-cooperation (both gain but facultative).

♥ **Positive interactions in agriculture**

Crop legumes (gram, soybean, lentil) rely on *Rhizobium* root nodules for nitrogen. Many fruit and vegetable crops (apple, mango, cucumber) depend on bee pollinators. Without these mutualisms, Indian agriculture loses an estimated 20–40% of yield.

Q 11.65 In an aquarium two herbivorous species of fish are living together and feeding on phytoplankton. As per the Gause's Principle, one of the species is to be eliminated in due course of time, but both are surviving well in the aquarium. Give possible reasons.

SOLUTION

Concept used. **Gause's Competitive Exclusion Principle** (1934) states that two species competing for exactly the same limiting resource cannot coexist indefinitely — one will be eliminated. The principle assumes (i) the resource is limiting, (ii) the two species' niches overlap completely, (iii) the environment is constant. If any assumption fails, coexistence is possible. The chapter discusses three escape routes: **resource partitioning**, **niche differentiation** and **spatial/ temporal separation**.

Step 1. Why both species survive — possible reasons.

- **Resource partitioning.** Although both feed on phytoplankton, they may pick different sub-types (one prefers diatoms, the other prefers cyanobacteria), splitting the same resource into non-overlapping fractions.
- **Spatial separation in the aquarium.** One species may feed predominantly in the upper water column (near the surface where light favours green algae); the other may feed near the bottom (where settled or shaded phytoplankton dominate).
- **Temporal separation.** One species may feed during the day, the other at dusk/night, reducing direct overlap.
- **Different feeding behaviour or size.** Different mouth size and gill-raker spacing let each fish capture phytoplankton of different size ranges.
- **Plentiful resource.** If phytoplankton is being continuously regenerated (aerated, lit aquarium with regular feeding), the resource may never become limiting — and Gause's principle only operates when the resource is limiting.
- **Stable/benign environment.** Aquaria are buffered (temperature, pH, dissolved oxygen kept stable). Stress that would normally tilt competition toward the better-adapted species is absent.

Step 2. **Conclusion.** Any one of the above (or a combination) breaks one of Gause's assumptions, allowing both species to coexist.

> **Final Answer:** Both species coexist because Gause's assumptions are violated — through resource partitioning, spatial or temporal separation, abundant non-limiting food, or a stable aquarium environment.

☞ **Quick recall**

Refer back to the chapter's sign-table for inter-specific interactions and the four organismic response strategies (regulate, conform, migrate, suspend) — both recur across most Exemplar questions in this chapter.

EXPERT'S SOLUTION *: Tara Iyer, M.Sc Botany, Delhi University*

Strategic angle. Gause's principle has hidden assumptions: limiting resource, complete niche overlap, constant environment. Identify which assumption the aquarium violates, and the answer writes itself.

Step 1. **Recap Gause.** Two species competing for the same limiting resource cannot coexist in the long run. One must go extinct (competitive exclusion).

Step 2. **What can rescue coexistence?**

- Resource is *not* limiting — abundant phytoplankton in a well-fed tank.

- Niches not fully overlapping — different phytoplankton sub-types or sizes consumed.
- Spatial niche separation — top vs bottom feeders.
- Temporal niche separation — day vs night feeders.

Step 3. **Apply to the aquarium.**

- Aquaria are typically over-supplied with food (the hobbyist adds flakes regularly). Phytoplankton is non-limiting.
- Stable temperature, pH and oxygen mean neither species is stressed; both maintain steady birth rates.
- Even slight spatial preferences (mid-water vs bottom) keep the two species effectively foraging in different micro-habitats.

Step 4. **Connection to MacArthur's warblers.** The same logic explains how five *Dendroica* warbler species coexist in North American conifers: each feeds at a different height and on a different branch zone. Gause's principle is intact because each species has its own micro-niche.

Step 5. **Generalisation.** "Two species can coexist if and only if they avoid competing for exactly the same limiting resource." This single sentence resolves apparent contradictions to Gause.

Step 6. **Aquarium summary table.**

- Resource overlap: partial $\rightarrow$ coexistence possible.
- Resource scarcity: non-limiting $\rightarrow$ coexistence possible.
- Environment: stable $\rightarrow$ neither species pushed out.

Why this matters. The same logic underlies fishery management: stocking two herbivorous carp species (silver carp + catla) in the same pond works because their feeding zones differ — silver carp at surface, catla in mid-water. Gause's principle does not forbid coexistence; it forbids *identical* niches.

> **Final Answer:** Aquarium conditions break Gause's assumptions: phytoplankton is over-supplied (non-limiting), the two species occupy slightly different sub-niches (size, depth, time), and the environment is buffered; so both species persist.

Q 11.66 While living in and on the host species, the animal parasite has evolved certain adaptations. Describe these adaptations with examples.

SOLUTION

Concept used. A **parasite** lives in (endoparasite) or on (ectoparasite) a host, drawing nutrition at the host's expense (sign − for host, + for parasite). Because the host environment is biologically rich but defensively hostile (immune attacks, gut peristalsis, grooming), endoparasites in particular have evolved a suite of specialised adaptations — many involving loss of structures no longer needed inside a host.

Step 1. **Morphological adaptations (mostly loss of organs).**

- **Loss of sense organs** — eyes, antennae, statocysts are useless inside a host's gut. Tapeworms and flukes have no eyes.
- **Loss of digestive system.** Tapeworms (*Taenia solium*) absorb pre-digested nutrients directly through their body wall; no mouth, no gut.
- **Adhesive/attachment organs.** Scolex of tapeworm bears hooks and suckers; flukes have oral and ventral suckers; head lice have grasping claws; ticks have a barbed hypostome.
- **Thick cuticle/tegument.** Resists host digestive enzymes (e.g. *Ascaris* has a tough cuticle that survives stomach acid).
- **Anaerobic respiration.** The host gut is low in oxygen; endoparasites have shifted to fermentation pathways.

Step 2. **Reproductive adaptations.**

- **Hermaphroditism** — most flatworm parasites are hermaphrodites, so a single individual in a host can self-fertilise.
- **High fecundity.** *Ascaris* female can lay 200,000 eggs/day. Most eggs die in the external environment; high output compensates.
- **Resistant eggs and cysts.** Tough shells survive desiccation, gut transit and even disinfection; cysts can wait years for a new host.
- **Multiple hosts in life cycle.** *Plasmodium* alternates between mosquito and human; *Taenia* alternates between pig (cyst) and human (adult worm).

Step 3. **Physiological/biochemical adaptations.**

- Resistance to host immune attack — surface antigen switching (*Trypanosoma*, *Plasmodium*), molecular mimicry of host molecules.
- Secretion of anti-coagulants by blood feeders (e.g. leeches secrete hirudin).

Step 4. **Take-away.** Parasitic life is paradoxical: it involves both extreme simplification (loss of unused organs) and extreme specialisation (attachment, immune evasion, multi-host cycles).

Final Answer: Loss of sense organs and gut; attachment organs (suckers, hooks); thick cuticle; anaerobic respiration; high fecundity; hermaphroditism; resistant eggs/cysts; multiple hosts in life cycle; immune evasion.

EXPERT'S SOLUTION *: Sneha Rao, M.Sc Microbiology, JNU*

Strategic angle. Group adaptations under three headings — morphological, reproductive, physiological — and give one or two named examples in each.

Step 1. Morphological — what is lost and what is gained.

- *Lost:* eyes, locomotory organs, gut (in tapeworms), nervous system simplification.
- *Gained:* suckers, hooks, anchors (scolex of tapeworm); barbed mouthparts (ticks); thick cuticle (*Ascaris*).

Step 2. Why lose structures? Inside a host's gut there is nothing to see, no need to swim, and digestion is already done. Selection favours individuals that don't waste energy building useless organs.

Step 3. Reproductive adaptations driven by transmission bottleneck.

- Few offspring reach a new host. Compensate by producing many — *Ascaris* female lays 200,000 eggs/day.
- Self-fertilising hermaphroditism guarantees fertilisation even when only one parasite is present in a host (most parasitic flatworms).
- Resistant cysts and eggs survive months outside a host.

Step 4. Physiological adaptations.

- Anaerobic metabolism in the low-O_2 gut.
- Surface coats that switch antigens to evade immunity (*Trypanosoma*'s VSG coat).
- Anti-coagulants in blood feeders (leech hirudin).

Step 5. Worked example — *Taenia solium*.

- No mouth or gut — absorbs nutrients across the tegument.
- Scolex has four suckers and a rostellum with hooks to anchor in the intestinal wall.
- Hermaphrodite proglottids — self-fertilises.
- Multi-host cycle: pig (cysticercus) $\rightarrow$ human (adult tapeworm).

Step 6. Worked example — *Pediculus humanus* (head louse, ectoparasite).

- Claws grasp hair shafts.

- Mouthparts pierce skin and suck blood.
- Reduced wings — flightless.

Why this matters. The same suite of adaptations recurs in unrelated parasite lineages — convergent evolution. Recognising the pattern lets you predict parasite biology even from species you've never studied.

> **Final Answer:** Loss of sense organs and gut; attachment hooks/suckers; thick cuticle; anaerobic metabolism; hermaphroditism + high fecundity; resistant cysts/eggs; immune evasion. Examples: *Taenia* (endo), *Pediculus* (ecto).

✗ Don't forget the host's response

"Parasitic adaptations" on its own often means the parasite's side only. A complete answer can also mention host counter-adaptations (immune system, behavioural grooming) as evidence of an arms race.

Revise the Chapter from the Class 12 Biology Notes →

Q 11.67 **Do you agree that regional and local variations exist within each biome? Substantiate your answer with suitable example.**

SOLUTION

Concept used. A **biome** is a large climatic–vegetation zone defined by mean annual temperature and precipitation (rainforest, savanna, desert, temperate forest, taiga, tundra). Within any biome, however, fine variations in topography, soil type, altitude, latitude and human history create **regional** (landscape-scale) and **local** (micro-habitat-scale) differences in species and community structure. So yes — regional and local variation are universal inside every biome.

Step 1. Why variation arises.

- *Topography.* Slope, aspect (north-facing vs south-facing), drainage and altitude alter temperature, moisture and light at sub-biome scale.
- *Soil.* Sandy, clayey, lateritic, alluvial, alkaline soils differ within a biome. Plants tuned to each soil type form different communities.
- *Latitude inside the biome.* The same biome at its equatorward edge differs from the same biome at its poleward edge.
- *Disturbance history.* Fire, flood, grazing and human cultivation create patchy successional stages.

Step 2. **Example 1 — tropical rainforest biome.**

- *Amazon basin* (South America): dominated by *Bertholletia* (Brazil nut), *Hevea* (rubber); home to jaguars and harpy eagles.
- *Congo basin* (central Africa): dominated by different tree species (*Aucoumea*, *Khaya* mahogany); home to forest elephants and gorillas.
- *Western Ghats* of India: smaller-scale wet evergreen forest with *Dipterocarpus*, *Hopea*; lion-tailed macaque, Nilgiri tahr.
- *Borneo and New Guinea*: dipterocarp giants with orangutans and birds of paradise.

All four are "tropical rainforest" yet contain entirely different species — regional variation within one biome.

Step 3. **Example 2 — desert biome.**

- Sahara (Africa): sand desert; succulents are rare; fennec fox, dromedary camel.
- Thar (India–Pakistan): more shrubby; *Acacia tortilis*, *Calotropis*; chinkara, blackbuck.
- Sonoran (USA–Mexico): true cactus desert; iconic saguaro cactus; roadrunner, rattlesnake.

All three are "deserts" but their flora and fauna differ sharply.

Step 4. **Example 3 — local variation inside one Indian forest.** Within the Sundarbans mangrove ecosystem, the seaward edge has *Avicennia* (high salt tolerance), the mid-tide zone has *Rhizophora*, and the landward edge merges into *Heritiera* (Sundari) — three distinct community zones within $200\,\text{m}$ of coast, all inside one mangrove biome.

Step 5. **Conclusion.** Biomes are useful generalisations but gloss over enormous internal heterogeneity. Conservation planning must work at the regional and local scale, not just the biome scale.

> **Final Answer:** Yes — regional (Amazon vs Congo vs Western Ghats) and local (mangrove tidal zones) variations exist inside every biome because topography, soil, latitude and disturbance vary at sub-biome scale.

☞ **NEET cue**

Exemplar phrasings in this chapter recycle the same dozen terms (stenothermal, eurythermal, halophyte, sciophyte, mutualism, amensalism, r, K). Memorising the prefix-to-meaning map turns most MCQs into one-line decodings.

EXPERT'S SOLUTION : *Aanya Verma, M.Sc Botany, Delhi University*

Strategic angle. Start with a clear "yes". Then give two examples — one showing inter-continental regional variation in the *same* biome (rainforest in Amazon vs Congo) and one showing local variation inside an Indian biome (Sundarbans tidal zones).

Step 1. Yes, variation is universal. Biomes are climate- defined; species composition responds to many other factors on top of climate.

Step 2. Regional example. The tropical rainforest biome looks the same on a climate map but its species composition differs across continents:

- Amazon: Brazil nut tree, jaguar, three-toed sloth.
- Congo: forest elephant, gorilla, okapi.
- Indo-Malayan (Borneo): orangutan, dipterocarp giants.

Each region has its own evolutionary history; species speciated in geographic isolation despite similar climate.

Step 3. Local example. Within Indian forests, walk 500 m from a hilltop to a streamside in the same district: the tree species, undergrowth, butterflies and birds all shift. Soil moisture and slope changes drive this.

Step 4. Mechanisms.

- Soil: laterite vs alluvium vs sand.
- Drainage: dry ridge vs wet hollow.
- Aspect: north-facing (cooler) vs south-facing (warmer).
- Fire history: recently burnt patches harbour pioneer species; long-unburnt patches reach climax.

Step 5. Conservation implication. Saving only one tract of "tropical rainforest" does not save all rainforest species — each region has unique endemics. Hence India's protected- area network covers multiple geographic units, not just one biome.

Step 6. Reading the textbook map. The chapter's biome map shows broad colour bands; do not be misled into thinking all of one colour is biologically identical.

Why this matters. Biome thinking is useful for global climate modelling; species-level conservation needs sub-biome resolution. The two scales complement each other.

> **Final Answer:** Yes — every biome shows regional variation (Amazon vs Congo rainforest) and local variation (Sundarbans tidal zones).

Q 11.68 **Which element is responsible for causing soil salinity? At what concentra-**

tion does the soil become saline?

SOLUTION

Concept used. **Soil salinity** is the build-up of soluble salts (chiefly **sodium chloride**, NaCl, plus sulphates and carbonates of Na, Mg, Ca) in the upper soil profile. The principal culprit ion is **sodium (Na^+)**, usually paired with chloride. A soil is classified as saline once its **electrical conductivity (EC)** of the saturation extract exceeds $4\,dS/m$ at $25\,°C$, corresponding to a soluble-salt content of roughly 0.1% (1 g salt per 100 g dry soil).

Step 1. **Element responsible.** Sodium (Na^+), typically deposited as NaCl. Other contributors: Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}, HCO_3^-. Sodium is highlighted because it also damages soil structure (deflocculation of clay).

Step 2. **Threshold concentration.**

- Conductivity criterion: EC $> 4\,dS/m$ (4 mmhos/cm).
- Salt-mass criterion: total soluble salts $> 0.1\%$ (≥ 1 g salt/100 g soil).
- Plant-physiology criterion: above this, most crop species (wheat, paddy, tomato) suffer yield loss from osmotic stress and Na toxicity.

Step 3. **Sources of salinity in Indian context.**

- Coastal inundation (Sundarbans, Gulf of Kutch).
- Excessive irrigation followed by evaporation leaves salt deposits at the surface — a major problem in canal-irrigated Punjab and Haryana.
- Capillary rise of saline groundwater in arid zones.

Step 4. **Plant response.** Only **halophytes** can tolerate $> 0.1\%$ salt (Salicornia, Atriplex, Suaeda, mangroves). Most crops are **glycophytes** and suffer beyond this threshold.

> **Final Answer:** Sodium (chiefly as NaCl) is the responsible element. Soil is classified saline when EC $> 4\,dS/m$, i.e. total salts above $\sim 0.1\%$.

♥ **Real-world tie-in**

The principle illustrated here also underlies practical decisions in conservation and agriculture — from why mangrove restoration needs salt-tolerant seedlings to why crop rotations with legumes (Rhizobium mutualism) raise yield without nitrogen fertiliser.

EXPERT'S SOLUTION : *Vivaan Iyer, Ph.D Molecular Biology, NCBS Bangalore*

Strategic angle. Two sub-questions: (i) the element, (ii) the threshold. Answer both crisply with numbers.

Step 1. **Element.** Sodium, deposited as NaCl (sometimes with sulphates).

Step 2. **Threshold (two equivalent statements).**

- Electrical conductivity (EC) of the saturation extract $> 4\,\text{dS/m}$.
- Soluble-salt mass $> 0.1\%$ of dry soil mass.

Step 3. **Why it matters.** Above this, crops suffer *osmotic stress* (water cannot enter roots) and *ion toxicity* (excess Na inside cells disrupts enzyme function).

Step 4. **Conversions.** 1 dS/m $\approx$ 640 ppm dissolved salt $\approx 0.064\%$. So $4\,\text{dS/m} \approx 2560\,\text{ppm} \approx 0.256\%$ in solution but $\approx 0.1\%$ on dry-soil basis (because the extract is more concentrated than the bulk soil water).

Step 5. **Remediation.** Saline soils are reclaimed by leaching with good-quality irrigation water (washes salts down the profile) and gypsum addition (Ca^{2+} displaces adsorbed Na^{+}, then leaches away).

Step 6. **India-specific.** **Reh** (a powdery white salt efflorescence on Indo-Gangetic plains) is a classic visible sign of Na-dominated salinity, common in Uttar Pradesh, Punjab and Haryana under canal irrigation.

> **Final Answer:** Sodium (as NaCl); soil is saline above EC $4\,\text{dS/m}$, i.e. $> 0.1\%$ salt by dry mass.

Connection to wider chapter. The point this question makes is reinforced elsewhere in the chapter: the same prefix and sign- table logic recurs in the MCQ block, the SA block on inter-specific interactions, and the LA discussion of population growth. Building this vocabulary once and reapplying it across question types is the fastest way to clear an Exemplar chapter at speed.
Practice cue. If a similar question appears in the board paper or NEET, restate the definition in one sentence, anchor it with one named Indian-context example, then commit to the option. Avoid second-guessing once the prefix or sign-table has been decoded — the chapter is designed so that a single decoding step selects the answer.

Q 11.69 **Does light factor affect the distribution of organisms? Write a brief note giving suitable examples of either plants or animals.**

SOLUTION

Concept used. Light is a fundamental abiotic factor: plants need it for photosynthesis; animals use it to time daily and seasonal activity (photoperiodism), to find food and mates, and to navigate. The intensity, duration and spectral quality of available light vary with latitude, altitude, depth (in water), tree canopy and time of day. Each of these gradients filters the species that can live there.

Step 1. Light affects plant distribution.

- **Heliophytes vs sciophytes.** Sun-loving plants (sunflower, *Tridax*) need full sunlight and cannot survive under dense canopy. Shade-loving plants (ferns, *Begonia*, *Oxalis*, money plant) need diffuse light and wilt in direct sun.
- **Vertical stratification in forests.** Tall trees control canopy light; smaller trees, shrubs and herbs adapt to progressively dimmer light below. Each layer holds a different assemblage.
- **Underwater stratification.** Red light is absorbed first; blue penetrates deepest. Deep-water algae (red algae like *Polysiphonia*, *Gelidium*) have accessory pigments (phycoerythrin) that capture blue light. Shallow- water algae (*Ulva*, green algae) work fine with red.
- **Photoperiodism in flowering.** Some plants require short days to flower (*Chrysanthemum*, rice, cotton — *short-day plants*); others need long days (spinach, lettuce — *long-day plants*). Daylength varies with latitude and season, restricting where each species can flower successfully.

Step 2. Light affects animal distribution and behaviour.

- **Diurnal vs nocturnal niches.** Light splits the 24-hour cycle into two niches: diurnal (eagles, butterflies, humans) hunt by day; nocturnal (owls, bats, leopards) hunt by night. Cave-dwelling animals (*Proteus* salamander) have lost eyes altogether.
- **Bioluminescence in the deep sea.** Below $\sim 1000\,\text{m}$ no sunlight penetrates; many deep-sea fish produce their own light (anglerfish, lanternfish) to attract prey or mates. These species are strictly limited to the dark zone.
- **Migration cued by photoperiod.** Many birds (*Siberian crane*, *Arctic tern*) time their migration by daylength. Distribution shifts seasonally between breeding and wintering grounds.
- **Reproductive timing.** Many fish, frogs and insects synchronise spawning to photoperiod cues — populations breed only where the right daylength pattern occurs.

Step 3. Conclusion. Light intensity, daylength and spectral quality each impose distinct distribution limits. No major group of organisms is independent of light.

> **Final Answer:** Yes — light intensity (heliophytes vs sciophytes; canopy stratification; deep-sea algae), photoperiod (flowering time, bird migration) and spectral quality (red vs blue underwater) all shape distribution of plants and animals.

✗ Avoid the trap

Don't confuse population-level attributes (rate, ratio, density) with individual-level attributes (age, sex, body mass). The Exemplar deliberately mixes both kinds in distractor options.

EXPERT'S SOLUTION *: Riya Banerjee, M.Sc Botany, Delhi University*

Strategic angle. Three dimensions of light — intensity, duration, quality — each map onto distinct distribution patterns. Cover at least two with one named example each.

Step 1. Intensity.

- Helio/scio split among plants.
- Canopy stratification: tall trees dominate the light supply; shrubs and herbs adjust.
- Underwater: red-algae versus green-algae depth zonation.

Step 2. Duration (photoperiod).

- Short-day plants (rice, *Chrysanthemum*) only flower where autumn daylengths are short.
- Long-day plants (spinach) only flower where summer daylengths are long.
- Bird migration timed by daylength.

Step 3. Quality (spectral composition).

- Phycoerythrin in red algae captures the blue/green light that reaches 30–100 m underwater.
- Bioluminescence in deep-sea fish.

Step 4. Examples mixed. *Tridax* (heliophyte weed), *Pteris* fern (sciophyte indoor), *Polysiphonia* (deep red alga), *Siberian crane* (photoperiod-cued migrant).

Step 5. Conclusion. Yes, light is a major distribution filter at every scale from a single forest to the entire ocean column.

Step 6. Cross-link. See SA Q4 for heliophyte/sciophyte and SA Q5 for underwater light attenuation.

Why this matters. Designing a botanic garden or an aquarium requires matching plants to the local light environment. The same logic explains why deforestation collapses understorey species first — once the canopy goes, the shade vanishes.

> **Final Answer:** Yes — light intensity, photoperiod and spectral quality each shape distribution; examples include heliophyte/sciophyte split, canopy stratification, and Siberian crane migration.

Cross-reference within the chapter. The principle invoked here is also used in the long-answer questions on community interactions and on growth curves. Recognising the same idea recycled across question types saves time on the Exemplar paper.
Take-away for revision. Note the named example used above in your formula sheet under "Organisms and Populations". The chapter's MCQs, VSAs and SAs repeatedly draw from a small canonical list of Indian-context examples — committing those to memory pays back across every section.
Where this fits in the chapter map. This idea sits at the intersection of the "abiotic factors $\rightarrow$ organismic responses" and "population attributes $\rightarrow$ growth models" threads. The sign-table for interactions, the four response modes (regulate, conform, migrate, suspend) and the two growth-curve shapes (J and S) are the chapter's three pillars; every Exemplar question is a variation on one of them.
Speed tactic. When a similar Exemplar question appears, identify which pillar it belongs to first — that immediately narrows the vocabulary and the canonical example set you need to draw on. The actual answer then falls out in a single line of reasoning.

Q 11.70 Give one example for each of the following:
(i) Eurythermal plant species (ii) A hot water spring organism (iii) An organism seen in deep ocean trenches
(iv) An organism seen in compost pit (v) A parasitic angiosperm (vi) A stenothermal plant species
(vii) Soil organism (viii) A benthic animal (ix) Antifreeze compound seen in antarctic fish (x) An organism which can conform

SOLUTION

Concept used. Each sub-question names an ecological category or adaptation; one named organism (or compound) per item is enough. Use the chapter's terminology for stenothermal/eurythermal, extremophile and benthos.

Step 1. (i) **Eurythermal plant species.** Tolerates a wide temperature range. Example: *Zea mays* (maize) — grown from tropical India to temperate Canada. Alternative: sunflower, eucalyptus.

Step 2. (ii) **Hot water spring organism.** Lives at $> 70\,°C$. Example: *Thermus aquaticus* (the bacterium that gave us *Taq* polymerase, from Yellowstone hot springs). Indian analogue: cyanobacteria of Tatapani springs. *Pyrococcus* and *Sulfolobus* archaea are also acceptable.

Step 3. (iii) **Organism in deep-ocean trenches.** Lives at $> 6000\,m$, in cold high pressure. Example: deep-sea anglerfish (*Melanocetus*), giant tube worms (*Riftia pachyptila*) at hydrothermal vents, or the snailfish *Pseudoliparis swirei* from the

Mariana Trench.

Step 4. (iv) **Organism in compost pit.** Decomposes organic matter. Examples: *Earthworms* (*Eisenia foetida* in vermicomposting), *Aspergillus* fungi, actinomycetes, bacteria of genus *Bacillus*.

Step 5. (v) **Parasitic angiosperm.** A flowering plant that parasitises another plant. Example: *Cuscuta* (dodder) — total stem parasite; *Rafflesia* — total root parasite with the largest flowers in the plant kingdom; *Orobanche* — total root parasite; *Viscum* (mistletoe) — partial stem parasite.

Step 6. (vi) **Stenothermal plant species.** Tolerates only a narrow temperature range. Example: orchids of cloud forests (*Dendrobium* of Himalayan slopes), coffee plant (*Coffea arabica* — narrow 18–24 °C optimum), apple, cardamom.

Step 7. (vii) **Soil organism.** Lives in soil. Example: earthworm (*Pheretima posthuma*), springtails (Collembola), mites (Acari), nematodes (*Caenorhabditis*), soil bacteria (*Nitrosomonas*).

Step 8. (viii) **Benthic animal.** Lives on or in the sea floor. Example: *Starfish* (*Asterias*), sea cucumber (*Holothuria*), oyster (*Crassostrea*), crab.

Step 9. (ix) **Antifreeze compound in Antarctic fish.** Glycoproteins called **antifreeze glycoproteins (AFGPs)** — discovered in *Trematomus* and *Dissostichus* Antarctic icefishes. They bind to nascent ice crystals and prevent them from growing, keeping blood liquid below the normal freezing point.

Step 10. (x) **Conformer.** An organism whose internal state tracks the external environment instead of regulating. Example: *Frog* (body temperature varies with surroundings — ectotherm + osmoconformer in fresh water); most marine invertebrates (sponges, jellyfish, marine worms, sea anemones) are osmoconformers.

> **Final Answer:** (i) Maize (ii) *Thermus aquaticus* (iii) Giant tube worm *Riftia* or deep-sea anglerfish (iv) Earthworm / Aspergillus (v) *Cuscuta* / *Rafflesia* (vi) Coffee plant / orchid (vii) Earthworm *Pheretima* (viii) Starfish (ix) Antifreeze glycoproteins (AFGPs) (x) Frog (ectothermic) / most marine invertebrates.

EXPERT'S SOLUTION *: Krishna Patel, M.Sc Zoology, Banaras Hindu University*

Strategic angle. For a "give one example" question, the safest pick is the textbook's canonical example. List one and move on; multiple synonyms (where given above) are bonus.

Step 1. Eurythermal plant — maize (*Zea mays*); grows 10–35 °C.

Step 2. Hot-spring — *Thermus aquaticus*; lives at 70–80 °C.

Step 3. Deep trench — *Riftia* tube worms at hydrothermal vents; live by sulphur-chemosynthetic symbionts.

Step 4. Compost — earthworm + *Aspergillus*.

Step 5. Parasitic angiosperm — *Cuscuta* (no chlorophyll, twines around hosts).

Step 6. Stenothermal plant — coffee (narrow 18–24 °C).

Step 7. Soil — earthworm *Pheretima*.

Step 8. Benthic — starfish.

Step 9. Antifreeze — *antifreeze glycoproteins* in Antarctic icefish.

Step 10. Conformer — *frog* (body temperature conforms to environment).

Why this matters. Each example is a representative of a broader category. Knowing the canonical pick for each one lets you answer "name an organism that lives in X" without re-thinking.

> **Final Answer:** See worked list above.

Linking to the rest of the syllabus. The same logic applies in Ecosystem (Chapter 12 in the 2026-27 syllabus) where energy flow and nutrient cycling depend on the species-level interactions discussed here, and in Biodiversity & Conservation (Chapter 13) where the conservation of mutualisms and pollinators is a recurring theme.
Recommended practice. Re-read the chapter table of positive interactions and run through one named Indian-context example for each. The Exemplar deliberately tests examples (not just definitions), so a handful of well-chosen examples per category is the most efficient revision strategy.
Why the chapter keeps returning to this idea. The Exemplar is structured so that each MCQ, VSA, SA and LA tests the same small set of core ideas at increasing depth. This question is one such variant; mastering the underlying principle once unlocks several other questions in the chapter.
Revision tip. Pair every definition you encounter in this chapter with one named Indian example (e.g. Sundarbans for mangroves, Western Ghats for biodiversity hotspot, Cuscuta for a parasitic angiosperm). The Exemplar examiners reward example- backed answers over bare definitions.

♥ Extremophiles in biotechnology

Taq polymerase from *Thermus aquaticus* powers all PCR. Antifreeze glycoproteins are studied for organ preservation and frost-resistant crops. The ecology of extremes is also industrial biotechnology in disguise.

Key Takeaways

- Ecology operates at six nested scales: individual < population < community < ecosystem < biome < biosphere. Autecology studies the single organism; synecology and above study collectives.
- Four abiotic factors — temperature, water, light, soil — govern where organisms live. Stenothermal/eurythermal, stenohaline/euryhaline pairs encode tolerance breadth.
- Organisms respond to environmental stress in four ways: *regulate* (homeostasis: mammals, birds), *conform* (let internal state track external: most invertebrates and fish), *migrate* (e.g. Siberian crane), or *suspend* (hibernation, aestivation, diapause).
- A population has emergent attributes — density, natality, mortality, sex ratio, age distribution — that no single organism has. $N_{t+1} = N_t + B + I - D - E$ tracks how density evolves.
- Age pyramids predict the future: triangular → growing ($r > 0$); bell → stable ($r \approx 0$); inverted urn → declining ($r < 0$).
- Exponential growth ($dN/dt = rN$, J-shape) assumes unlimited resources. Logistic growth ($dN/dt = rN(K - N)/K$, S-shape) introduces a carrying capacity K and is the realistic model.
- Inter-specific interactions follow a sign table: mutualism $(+, +)$, commensalism $(+, 0)$, predation/parasitism $(+, -)$, competition $(-, -)$, amensalism $(-, 0)$. Each has canonical Indian-context examples.
- Gause's competitive-exclusion principle: two species cannot coexist while competing for an identical limiting resource. Coexistence in nature relies on niche differentiation, resource partitioning or abundant non-limiting resources.

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