Chapter 01: Understanding Environment and Ecology

A.	ENVIRONMENT

Introduction:

Why Are We Studying Environment?

Every living being depends on its surroundings for food, energy, water, oxygen and shelter, and in turn changes those surroundings. Human activities such as farming, industry and urbanisation also alter the environment. To understand ecosystems, biodiversity, pollution and climate change, we first need to be clear about what the environment is and what it is made of.

What Is Environment?

DEFINITION

Environment is everything around an organism that **affects it** and that it **affects in return**. The word comes from the French ***environ***, meaning "to surround".

- Organisms depend on it for food, energy, water, oxygen and shelter.

Legal definition: Environment (Protection) Act, 1986, Sec 2(a)

Environment includes **water, air and land**, and the **inter-relationships** among them and with **human beings, other living creatures, plants, micro-organisms and property**.

This is an **inclusive, not exhaustive** definition, so courts can widen it.

Natural vs Human-made Environment

NATURAL ENVIRONMENT	HUMAN-MADE ENVIRONMENT
Meaning: Everything that exists naturally, without human creation. **Examples:** Air, water, soil, sunlight, forests, rivers, wildlife. **Also called:** Physical environment.	**Meaning:** Surroundings created or modified by humans. **Examples:** Buildings, roads, dams, farms, industries, cities. **Also called:** Anthropogenic / built environment.

Illustration:

ILLUSTRATION

A Day in the Life of a Tiger

A tiger wakes up in the forest and begins its day. The trees provide it with shelter, deer become its prey, while sunlight, water, temperature and soil shape the conditions in which it lives. All these living (biotic) and non-living (abiotic) factors together influence the tiger's life. This entire surrounding is what we call its **Environment**.

Key Takeaways:

MEANING	Environment = everything around an organism that affects it and that it affects in return. Word from French environ.
LEGAL VIEW	EP Act 1986, Sec 2(a): water, air, land and their inter-relationships with humans, living creatures, plants, micro-organisms and property. An inclusive definition.
TYPES	Natural (not created by humans) and human-made (built by humans).

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Q. Which of the following most appropriately defines the term 'Environment'?

(a) The functional unit comprising living organisms and non-living components interacting through energy flow and nutrient cycling.

(b) The totality of living and non-living surroundings that influence the existence, growth and survival of an organism.

(c) The sum total of biological communities interacting with one another within a defined geographical area.

(d) The physical surroundings comprising air, water and land, excluding living organisms and their activities.

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B. ECOLOGY

Introduction:

DEFINITION

Ecology is the scientific study of how living organisms interact with each other and with their physical surroundings.

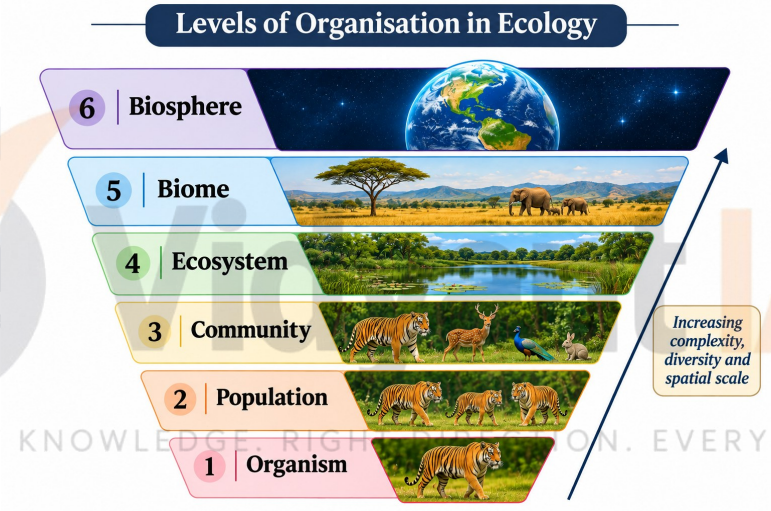
Word origin: Greek oikos (home) + logos (study). The term was coined by Ernst Haeckel in 1866.

Ecology does not study organisms in isolation; it studies how living organisms interact with one another and with their surrounding environment.

These interactions occur at different levels, starting from a single organism and gradually expanding to the entire living world.

To understand these ecological relationships systematically, ecologists classify them into different levels of organisation which forms a sort of ecological hierarchy as given below:

Levels or Organisation in Ecology



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The six levels of ecological organisation are:

1. Individual Organism: At the lowest level of the hierarchy are individual organisms. It can be a plant, an animal, a microorganism, etc.

Example: A tiger.

2. Population: A population consists of a group of individuals of the same species living in a particular area at a particular time.

Example: A group of tigers.

3. Community: A community is composed of multiple populations of different species living in a particular area at a particular time.

Example: A group of tigers, deer and peacock.

4. Ecosystem: An ecosystem is the structural and functional unit of nature, in which living (biotic) organisms interact with one another and with the non-living (abiotic) components of their environment, forming an interconnected system. In simple words: It is a system where living organisms and their physical surroundings interact and depend on each other.

Examples: Forest ecosystem, pond ecosystem, grassland ecosystem.

5. Biome: A biome is a large-scale ecological region characterized by distinct climate, vegetation, and animal life. Biomes are defined by factors such as temperature, precipitation, and soil type which makes every biome unique.

Example: tropical rainforest, desert.

6. Biosphere: The biosphere is that part or zone of the earth where life exists. It includes all the zones where life exists right from the deepest ocean trenches to the highest mountain peaks and includes various ecosystems such as forests, grasslands, deserts, oceans, and freshwater bodies. The biosphere interacts with the atmosphere, hydrosphere, and lithosphere, forming a complex web of relationships.

Understanding ecological hierarchy helps us study how living organisms interact with each other and their environment, from the smallest level (organism) to the largest level (biosphere).

Illustration:

ILLUSTRATION

Sheru the Tiger and the Ecological Hierarchy

Imagine Sheru, a tiger, exploring his forest. He is an organism; with other tigers, he forms a population. Along with deer, birds and plants, they become a community. But the forest is more than just living beings! Sunlight, flowing water, air and soil also play an important role. Their interaction with living organisms forms an ecosystem. This forest belongs to a larger biome, and all the world's biomes together form the biosphere – our living Earth!

Key Takeaways:

MEANING	Ecology is the scientific study of how living organisms interact with each other and with their physical surroundings.
ORIGIN	Greek oikos (home) + logos (study); coined by Ernst Haeckel in 1866.
HIERARCHY	Organism → Population → Community → Ecosystem → Biome → Biosphere (increasing complexity, diversity and spatial scale).

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Q. A researcher is studying a tropical forest. She first records a group of elephants of the same species, then studies their interactions with deer, birds and trees. She subsequently examines how these organisms interact with water, soil, sunlight and temperature. Finally, she compares this forest with other large geographical regions having distinct climatic and vegetation characteristics.

Which of the following correctly identifies the ecological levels represented by these successive observations?

(a) Population → Community → Ecosystem → Biome

(b) Community → Population → Ecosystem → Biosphere

(c) Population → Ecosystem → Community → Biome

(d) Organism → Community → Biome → Biosphere

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C. BASIC CONCEPTS AND TERMINOLOGY IN ECOLOGY

Biotic and Abiotic

Biotic Components

Meaning of Biotic Components

- The word Biotic is derived from the Greek word Bios, which means Life. Biotic components refer to the living organisms present in an ecosystem. They include plants, animals and microorganisms that interact with one another and with the abiotic components of the environment. They play different roles in maintaining the functioning of an ecosystem.

Examples: Trees, grasses, birds, insects, humans, fungi, bacteria, algae and other microorganisms.

Types of Biotic Components

Based on their functional roles in an ecosystem, biotic components are broadly classified into three categories:

1. Producers – Autotrophs (Self-nourishing)

Producers are organisms that prepare their own food using simple inorganic substances. They form the foundation of almost every ecosystem because they supply food and energy to other organisms.

Why are they called Autotrophs?

The word Autotroph is derived from:

- Auto = Self
- Troph = Nourishment or feeding

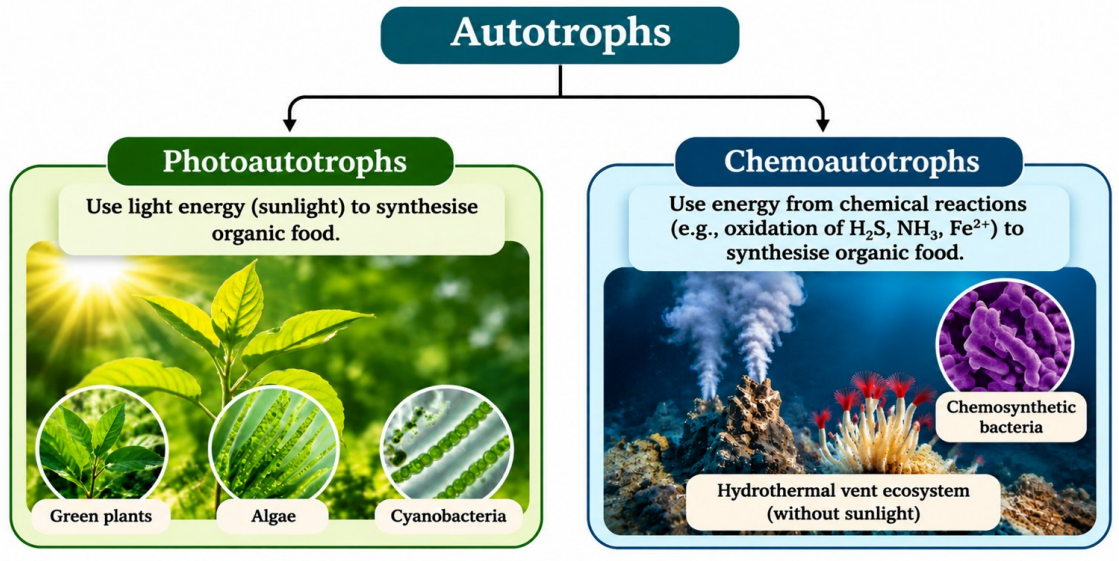
Thus, autotrophs are organisms that nourish themselves by preparing their own food.

Examples:

- Green plants
- Algae and phytoplankton
- Cyanobacteria
- Certain bacteria and archaea

Types of Autotrophs

Autotrophs can be classified according to the source of energy they use.



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Photosynthesis by Photoautotrophs

DEFINITION

Photosynthesis is the process by which green plants, algae and certain bacteria use light energy to convert carbon dioxide and water into organic food (carbohydrates).

Requirements:

Sunlight: Source of energy.

Chlorophyll / photosynthetic pigments: Capture light energy.

CO_2: Source of carbon.

Water: Provides electrons and hydrogen in oxygen-releasing photosynthesis.

Inputs: Carbon dioxide (CO_2) + Water (H_2O) + Light energy.

Outputs: Carbohydrates (represented by glucose) + Oxygen (O_2)

(Oxygen is released during oxygenic photosynthesis. Not all forms of bacterial photosynthesis release oxygen).

Key points to remember:

- Converts light energy into chemical energy.
- It is the primary energy-capturing process in most ecosystems.
- Green plants are major producers in terrestrial ecosystems.
- Phytoplankton (microscopic algae and cyanobacteria) are important producers in aquatic ecosystems.
- Photosynthesis is not limited to green plants; certain bacteria also perform it.

Chemosynthesis by Chemoautotrophs

DEFINITION

Chemosynthesis is the process by which certain bacteria and archaea use energy released from chemical reactions to convert carbon dioxide or other inorganic carbon sources into organic food, without requiring sunlight.

Requirements:

Inorganic substances: Such as hydrogen sulphide (H_2S), ammonia (NH_3), hydrogen (H_2) and ferrous iron (Fe^{2+}).

Chemical energy: Obtained through oxidation of these substances.

Carbon dioxide (CO_2): Commonly used as a carbon source to synthesise organic matter.

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Process:

- Chemoautotrophs obtain energy by oxidising inorganic substances.
- The energy released is used to synthesise organic compounds from inorganic carbon.

Example: Deep-sea hydrothermal vents

Illustration:

ILLUSTRATION

Producers: Making Their Own Food

Whether it is a plant preparing food using sunlight in a forest or bacteria preparing food using chemical energy in the dark depths of the ocean, both are doing the same fundamental job – manufacturing their own food.

That is why both are called Producers (Autotrophs) and form the foundation of their respective ecosystems.

2. Consumers – Heterotrophs (Other-nourishing)

Consumers are organisms that cannot prepare their own food. They depend on plants or other animals for their food and energy. They obtain food by consuming other organisms.

Why are they called Heterotrophs?

The word Heterotroph is derived from:

- Hetero = Other

- Troph = Nourishment or feeding

Thus, heterotrophs depend on other organisms for nourishment.

Types of Consumers

Consumers can be classified according to their food habits and trophic levels.

A. Primary Consumers

Primary consumers, also known as herbivores, are organisms that feed directly on producers. They obtain energy and nutrients by consuming plant material or algae.

Examples: Rabbits, deer, grazing animals like cows and sheep.

B. Secondary Consumers

Secondary consumers are organisms that feed on primary consumers. They obtain energy by consuming herbivores or other primary consumers. They can be carnivores or omnivores.

Examples: Carnivorous animals like snakes, frogs and small mammals like foxes and coyotes.

What are Carnivores and Omnivores?

- Carnivores are animals that eat other animals (flesh-eating organisms).
- Omnivores are animals that eat both plants and animals.

C. Tertiary Consumers

Tertiary consumers are organisms that feed on secondary consumers. They obtain energy by consuming other carnivores or omnivores.

Examples: Top predators such as large carnivores like lions, tigers, wolves, and apex predators like sharks in aquatic ecosystems.

Illustration:

ILLUSTRATION

The Hungry Deer

Imagine a hungry deer wandering through a forest. Unlike a green plant, it cannot prepare its own food using sunlight. It must depend on grass, leaves and other plants to satisfy its hunger. Similarly, all animals depend directly or indirectly on other organisms for food and are therefore called Consumers (Heterotrophs).

3. Decomposers – Saprotrophs (Decomposer organisms)

Decomposers are organisms that break down dead plants, animals and organic matter into simpler substances. They release nutrients back into the environment, making them available for reuse by producers. They play an important role in nutrient recycling.

Why are they called Saprotrophs?

The term Saprotroph is derived from:

- Sapro = Rotten or decaying
- Troph = Nourishment or feeding

Thus, saprotrophs obtain nourishment from dead and decaying organic matter.

How do they work?

They secrete digestive enzymes onto dead organic matter. These enzymes break down complex organic substances into simpler soluble substances. The decomposers absorb the resulting nutrients.

Examples: Bacteria, Fungi (mushrooms and moulds)

Illustration:

ILLUSTRATION

Nature's Recycling Team

After a long life in the forest, a giant tree finally falls to the ground. As days pass, tiny fungi and bacteria begin breaking down its dead remains, releasing nutrients back into the soil. These nutrients become available for plants to use again, making decomposers nature's own recycling team.

Important distinction: Decomposers vs Detritivores

Decomposers	Detritivores
Break down organic matter externally using enzymes	Feed by ingesting dead organic matter
Bacteria and fungi	Earthworms, millipedes and some insects

Abiotic Components

Abiotic components are the non-living factors that shape the structure of ecosystems. These include physical factors such as climate, soil, water, and topography, as well as chemical factors like nutrients and pH levels.

Illustration:

ILLUSTRATION

The Pond Ecosystem

On a hot summer afternoon, a pond receives sunlight, water flows into it from a nearby stream, air circulates above it, and minerals remain dissolved in its water. None of these components is alive, yet together they influence the survival and functioning of the pond ecosystem. These non-living components are called Abiotic Factors.

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Key Takeaways:

PRODUCERS	
MEANING	Producers are autotrophs (Auto = Self, Troph = Nourishment); they prepare their own food using simple inorganic substances.
TYPES	Photoautotrophs use light energy (photosynthesis); chemoautotrophs use energy from chemical reactions (chemosynthesis), without sunlight.
ROLE	They form the foundation of almost every ecosystem by supplying food and energy to other organisms.
CONSUMERS	
MEANING	Consumers are heterotrophs (Hetero = Other, Troph = Nourishment); they cannot prepare their own food and depend on plants or other animals.
TYPES	Primary consumers (herbivores) feed on producers; secondary consumers feed on primary consumers; tertiary consumers feed on secondary consumers.
EXAMPLES	Rabbits and deer (primary); snakes, frogs, foxes and coyotes (secondary); lions, tigers, wolves and sharks (tertiary).
DECOMPOSERS	
MEANING	Decomposers are saprotrophs (Sapro = Rotten or decaying); they break down dead plants, animals and organic matter into simpler substances.
HOW IT WORKS	They secrete digestive enzymes onto dead organic matter, which break it into simpler soluble substances that they absorb.
ROLE	They release nutrients back into the environment for reuse by producers, playing an important role in nutrient recycling.
ABIOTIC COMPONENTS	
MEANING	Abiotic components are the non-living factors that shape the structure of ecosystems.
PHYSICAL FACTORS	Climate, soil, water and topography.
CHEMICAL FACTORS	Nutrients and pH levels.

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Q. An ecosystem is found to have microorganisms that synthesise organic compounds using energy released from chemical reactions occurring in the absence of sunlight. The same ecosystem also contains organisms that feed on dead and decaying organic matter.

Consider the following statements:

1. **The microorganisms described above are examples of chemoautotrophs.**
2. **The process of food synthesis described above is known as photosynthesis.**
3. **Organisms feeding on dead organic matter may include detritivores.**
4. **All organisms involved in the decomposition of dead organic matter are necessarily detritivores.**

Which of the statements given above are correct?

(a) 1 and 3 only

(b) 1, 2 and 3 only

(c) 2 and 4 only

(d) 1, 3 and 4 only

Section D: Interactions in the Environment

D1 INTERACTIONS IN THE ENVIRONMENT

Living organisms do not exist in isolation; they constantly interact with their surroundings to meet their needs and survive.

Every interaction is one of two kinds:

- **Level 1:** Biotic ↔ Abiotic (organism and its non-living surroundings)
- **Level 2:** Biotic ↔ Biotic (organism and other organisms)

Biotic ↔ Abiotic Interactions:

Living things use, depend on, and also change the non-living environment. The effect runs both ways. Some of the interactions are given as bellows:

	How it works?	Examples
Shelter & habitat	Rocks, soil and wood provide protection.	Squirrel in a tree hollow; ants under a rock.
Navigation & cues	Organisms use the Sun, magnetic fields, etc., for navigation.	Birds migrate using the Sun; turtles return to nesting beaches using Earth's magnetic field.
Reproduction & dispersal	Wind, water and temperature carry seeds or trigger breeding.	Wind carries dandelion seeds; water carries coconuts; temperature triggers flowering.
Soil enrichment	Living organisms improve the non-living soil.	Earthworms and fungi return N, P and K to the soil.

Two directions to remember

Abiotic → Biotic: light, temperature, water, salinity, soil chemistry and altitude decide who can live where.

Biotic → Abiotic: plants release oxygen and bind soil; decomposers build humus; organisms drive nutrient cycles and ecological succession.

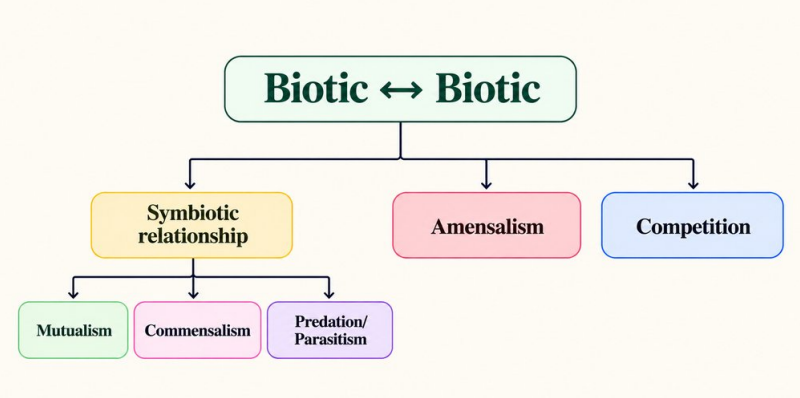
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D2 BIOTIC ↔ BIOTIC INTERACTIONS

Biotic interactions refer to the relationships or interactions between living organisms. These interactions influence their survival, growth, reproduction and distribution.

The nature of an interaction is represented using three symbols:

- **(+) Positive:** Organism benefits.
- **(−) Negative:** Organism is harmed.
- **(0) Neutral:** Organism is neither benefited nor harmed.



1. Symbiotic Relationship

> **Meaning**: A symbiotic relationship is a close and long-term association between two organisms belonging to different species, in which they live in close association and interact with each other.

It may involve:

Mutualism (+/+): Both organisms benefit.

Commensalism (+/0): One benefits, while the other remains unaffected.

Parasitism (+/−): One benefits, while the other is harmed.

A. Mutualism (+ / +)

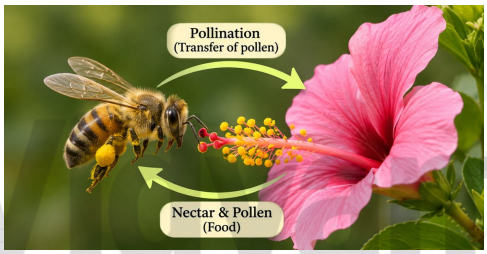
> **Meaning**: An interaction between two different species in which both organisms benefit.

Illustration:

ILLUSTRATION

Bee and Flower

A bee visits a flower in search of nectar and pollen for food. As it moves from one flower to another, it helps in pollination, enabling the plant to reproduce and form seeds and fruits. Thus, both benefit from each other.



Other examples:

Lichen: association between algae/cyanobacteria and a fungus.

Mycorrhiza: association between fungi and plant roots.

B. Commensalism (+ / 0)

> **Meaning**: An interaction in which one organism benefits, while the other is neither benefited nor harmed.

Illustration:

ILLUSTRATION

Orchid and Tree

An orchid finds a place to grow on the branch of a tree, gaining support and better access to sunlight. The tree, however, remains unaffected. Thus, the orchid benefits while the tree neither gains nor loses anything.



ADDITIONAL INFORMATION

Orchid is a common example of epiphyte.

But what are epiphytes?

Epiphytes are plants that grow on other plants, usually trees, for physical support and better access to sunlight. They do not obtain food from the host tree.

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Other example: Remora fish attaches to a shark and gets transport and leftover food, while the shark is generally unaffected, birds nesting in trees.

If the host is even slightly harmed (e.g., a heavy load of epiphytes breaking branches), it is no longer pure commensalism.

C. Parasitism (+ / −)

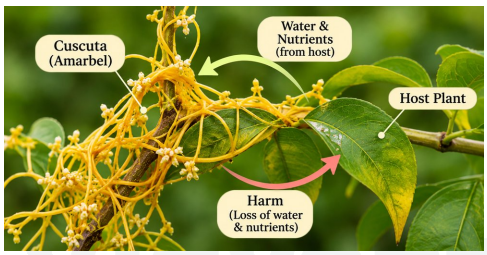
> **Meaning**: An interaction in which the parasite lives on or in a host, takes food (and often shelter) from it, and harms it, but usually does not kill it quickly.

Illustration:

ILLUSTRATION

Cuscuta (Amarbel) and Host Plant

Cuscuta wraps itself around a host plant and draws water and nutrients from it to survive. While Cuscuta benefits from this association, the host plant suffers harm.



Parasites further divided into Ectoparasites and Endoparasites. Ectoparasites live outside (lice, ticks); endoparasites live inside (tapeworm).

D. Predation (+ / −)

> **Meaning**: An interaction in which one organism (predator) kills and consumes another organism (prey).

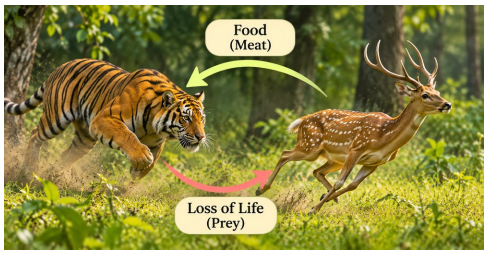
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Illustration:

ILLUSTRATION

Tiger and Deer

Imagine a tiger silently stalking a deer in the forest. With a sudden chase, the tiger catches its prey and feeds on it. The tiger gets its food, while the deer loses its life. This is a classic example of predation.



Other examples: Lion–zebra, snake–rat and frog–insect.

(Difference between Parasitism and Predation: In parasitism, the parasite lives on or inside the host and obtains nourishment from it, usually without killing it immediately. In predation, the predator hunts, kills and consumes its prey.)

2. Amensalism (− / 0)

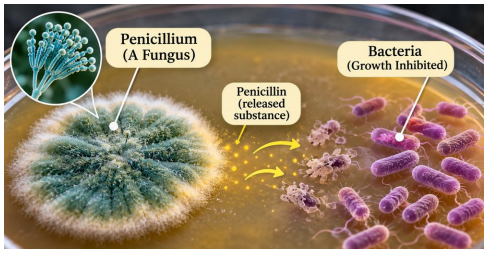
> **Meaning**: An interaction in which one organism is harmed, while the other remains unaffected.

Illustration:

ILLUSTRATION

Penicillium and Bacteria

Penicillium, a type of fungus, has an interesting way of affecting nearby bacteria. It releases a substance called penicillin, which inhibits the growth of certain bacteria, while the fungus itself remains largely unaffected. Thus, the bacteria are harmed, while Penicillium remains unaffected.



Other example: A large tree may shade a smaller plant and restrict its growth, while the large tree remains unaffected.

Related term:

— Allelopathy: The release of chemicals by one plant that influence the germination, growth or survival of other plants. It can be inhibitory or stimulatory.

3. Competition (− / −)

> **Meaning**: An interaction in which two or more organisms require the same limited resource, adversely affecting both. Competition becomes significant when resources are limited.

Illustration:

ILLUSTRATION

Tiger and Leopard

Deep in the forest, a tiger and a leopard are both on the lookout for deer. With deer being a limited food resource, both predators must compete to secure their meal. As one gets its share, less food may remain for the other. Thus, both are affected by competition for the same resource.



Other examples:

Two plants competing for sunlight, water and nutrients.

Two animals competing for territory.

Types of competition:

Intraspecific: Competition between individuals of the same species. Example: Two male deer competing for a mate.

Interspecific: Competition between individuals of different species. Example: Tiger and leopard competing for prey.

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Key Takeaways:

Interaction	Signs	Effect	Standard example
Mutualism	**+ / +**	Both gain	Bee–flower
Commensalism	**+ / 0**	One gains, other unaffected	Orchid–tree
Parasitism	**+ / −**	Parasite gains, host harmed (usually survives)	Cuscuta–host
Predation	**+ / −**	Predator gains, prey killed	Tiger–deer
Amensalism	**− / 0**	One harmed, other unaffected	Penicillium–bacteria
Competition	**− / −**	Both harmed	Tiger–leopard

UPSC PRELIMS PRACTICE MCQ

Question 1

On the trunk of a tall rainforest tree, a fern grows in a moist crevice of the bark, receiving more light than it would on the forest floor. It takes no water or nutrients from the tree. Measurements show that the tree's growth and seed output are the same with or without the fern.

The relationship between the fern and the tree is best described as:

(a) Commensalism

(b) Mutualism

(c) Parasitism

(d) Amensalism

Question 2

Assertion (A): Parasitism and predation are both (+/−) interactions, yet they are treated as distinct ecological relationships.

Reason (R): Ectoparasites such as ticks live on the outer surface of the host, while endoparasites such as tapeworms live inside the host.

Select the correct answer using the code given below:

(a) Both A and R are correct, and R is the correct explanation of A.

(b) Both A and R are correct, but R is not the correct explanation of A.

(c) A is correct, but R is incorrect.

(d) A is incorrect, but R is correct.

Question 3

In a dry deciduous forest, ecologists studied a tall tree species (T) and a low-growing herb (H) found beneath its dense canopy. Where T was present, H plants were stunted and produced far fewer seeds because of deep shade. In experimental plots from which all H plants were removed, T showed no change in growth or seed output compared with plots where H was present.

The ecological interaction between T and H is best described as:

(a) Competition

(b) Parasitism

(c) Commensalism

(d) Amensalism

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