Chapter 25

ECOLOGY

STUDENTS'LEARNING OUTCOMES

After studying this chapter, the students will be able to:

- Define species, population, community and ecosystem.
- Define biogeochemical cycles and locate the primary reservoirs of the chemicals in these cycles.
- Describe the water cycle in detail.
- Discuss nitrogen cycle in detail.
- Discuss the loss of energy between trophic levels.
- Describe characteristics of a population, such as growth, density, distribution, carrying capacity, minimum/viable size.
- Explain the effect of growth of human population on the ecosystem.
- Explain the greenhouse effect with examples of gases that exhibit this behavior.
- Describe the harmful effects of greenhouse gases on the environment.
- Describe four important ecosystems of Pakistan.

All organisms have certain requirements for life. They fulfill the requirements by interacting with other organisms and with the physical environment. Ecology is the study of the relationships of organisms with other organisms and the environment. In this chapter, you would get learning on the basic concepts of environment and the cycling of materials and energy between the environment and organisms.

25.1- Levels of Ecological Organization

To understand how life works, we must look through different "levels" on which natural world is organized into layers of increasing complexity.

1. Species: The Unit of Life

A species is the basic unit of biological classification. It refers to "a group of organisms that share similar physical and genetic characteristics and, most importantly, can interbreed to produce fertile offspring". For example, The Indus River Dolphin is a distinct species. All Indus dolphins can breed with one another, but they cannot breed with other types of dolphins to produce fertile young.

2. Population

A population is a group of individuals belonging to the same species living in the same geographic area at the same time. A species refers to a "type" of organisms globally, while a population refers to a specific group in a specific location. For example, all the Markhors living in the Chitral Gol National Park form a single

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population. If we consider Markhors across all of Pakistan, we are referring to the species; if we consider only about those in Chitral, we are referring to a population.

3. Community

In nature, no population lives alone. A community consists of all the different populations of various species living and interacting in the same area. This includes plants, animals, fungi, and bacteria. For example, a Mangrove Forest in Karachi refers to a community that includes the Mangrove trees, the mudskipper fish, the crabs, and the various shorebirds. They all share the same space and interact with one another (e.g., birds feed on fish).

4. Ecosystem

Communities live in ecosystems. An ecosystem consists of the biotic (living) components and the abiotic (non-living) components of the environment, such as sunlight, soil, water, and air. In an ecosystem, energy flows unidirectionally while the nutrients cycle between the living and the non-living parts.

For example, the Thar Desert is a vast ecosystem. It not only contains the snakes, blackbucks, and shrubs (the community); but also has the baking heat, the shifting sand dunes, and the rare rainfall (the abiotic factors) that influence the lifestyle of the organisms living in it.

5. Biome

A biome is a large, distinct geographical region characterized by its specific climate, soil altitude, and types of plants and animals which are adapted to those conditions.

In Pakistan, the diverse geography makes several biomes. For example; Coniferous Forest Biome is located in the high-altitude areas of Murree and Swat, where cold winters and pine trees dominate. Desert Biome is located in the Thal and Thar regions, characterized by low rainfall and specialized "succulent" plants like cacti. Similarly, Freshwater Biomes include the massive Indus River system.

6. Biosphere

The biosphere is the highest and most inclusive level of ecological organization. It is the global sum of all biomes. It refers to every part of the Earth where life exists - from the deepest trenches of the Arabian Sea to the highest peaks of the Himalayas, and even several kilometers up into the atmosphere.

Tidbit

The biosphere is often called the "Global Ecosystem". It is a thin "envelope" around the Earth where the lithosphere (land), hydrosphere (water), and atmosphere (air) interact to support life.

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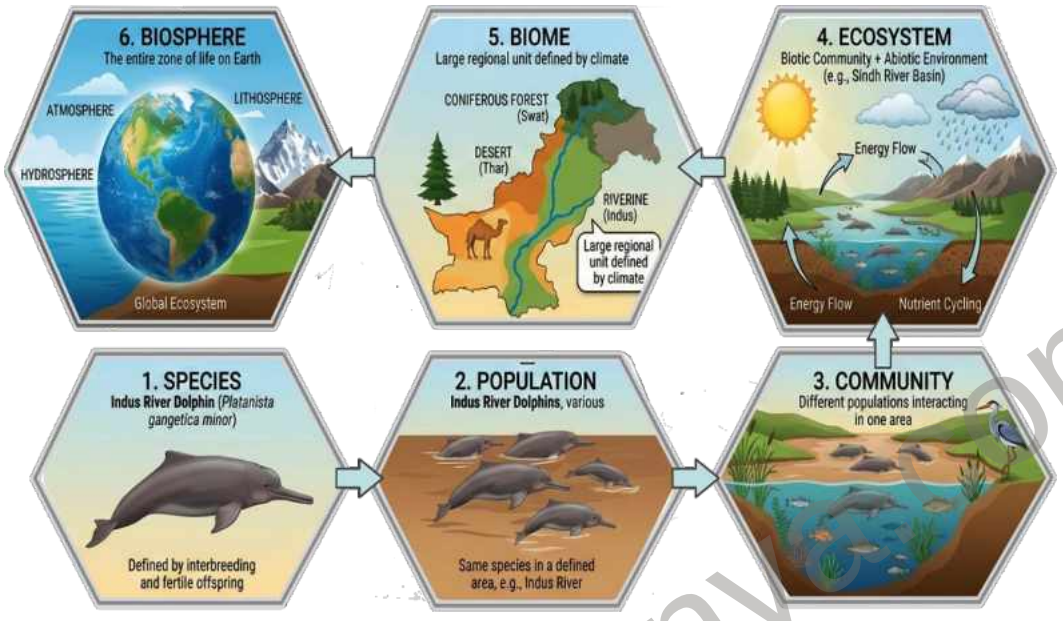

Figure 25.1: Levels of ecological organization

25.2- Biogeochemical Cycles

Biogeochemcial cycles are the cyclic movements of chemical elements – such as carbon, nitrogen, oxygen, phosphorous – between the living (biotic) and non-living (abiotic) components of ecosystem.

Primary Reservoirs of Biogeochemical Cycles

A primary reservoir ("sink" or "pool") is a massive component of the biosphere where the element of a biogeochemical cycle is stored for long periods of time. On the basis of primary reservoir, the biogeochemical cycles are classified as;

- **Gaseous cycles**, in which the reservoir is the air or the oceans (via evaporation). Gaseous cycles include nitrogen cycle, oxygen cycle, carbon cycle, and water cycle.
- **Sedimentary cycles**, in which the reservoir is Earth's crust. Sedimentary cycles include phosphorus cycle, sulfur cycle, and calcium cycle etc.

25.2.1- The Water Cycle

The water cycle (hydrological cycle) is the continuous movement of water between abiotic components (air, soil, and sea) and biotic components.

Tidbit
In a country like Pakistan, where our agriculture and economy depend entirely on the Indus River system, the water cycle is the literal lifeline of the nation.

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Abiotic Loop

1. Evaporation: The sun powers the entire water cycle. Solar radiation heats the surface water in oceans and lakes. It provides enough energy for water molecules to evaporate in the form of vapors. About 86% of global evaporation occurs from the oceans. In Pakistan, the Arabian Sea serves as the massive primary source of vapor that eventually travels inland.

2. Condensation: As water vapors rise into the atmosphere, they loses heat. When the air becomes cold enough, the vapors turn back into liquid droplets or ice crystals. These droplets cling to dust particles in the air to form clouds.

3. Precipitation: When the water droplets in clouds become too heavy, they fall due to gravity. Depending on the temperature, water falls as rain, snow, or sleet (a rain mingled with snow or hail).

4. Infiltration and Runoff: Once water hits the land, it takes one of two main paths to complete the cycle:

- **Infiltration:** Water seeps into the soil (percolation). It moves downward to reach the water table. This stores water underground as groundwater.
- **Surface Runoff:** It is the unconfined flow of water over the land surface. It occurs when water can no longer infiltrate into the soil. The surface runoff water flows into streams, rivers, and eventually to the oceans.

Tidbit
In Pakistan, surface runoff feeds the Indus River, while infiltration recharges the aquifers, we use for drinking water.

Biotic Loop

1. Water Entry into the Biotic Component: Water enters biotic components primarily through two methods. Terrestrial plants use root hairs to absorb water from the soil and use it for photosynthesis and as a structural support (turgor pressure). Animals take in water by drinking directly from freshwater sources and by eating food.

2. Water Exit from the Biotic Component: Once water has served its purpose inside an organism. it returns into the abiotic environment. **Transpiration** in plants is the major exit point for water. Plants release water vapors in atmosphere through the stomata present in their leaves. **Respiration** in plants and animals also produces water as a byproduct. This "metabolic water" is exhaled as vapors. In **excretion** and **egestion**, animals also release water through urine and feces, returning it to the soil or water bodies. During perspiration (sweating), animals release water through skin pores, which evaporates to the atmosphere. **Decomposition** of organisms' dead bodies also releases water back into the soil or atmosphere.

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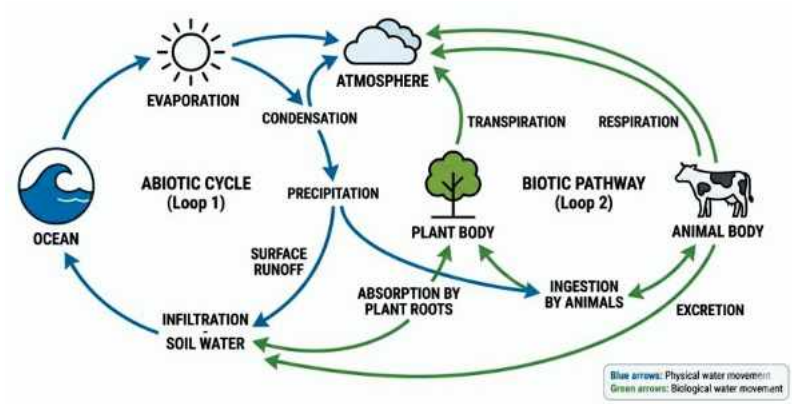

Figure 25.2: The steps of water cycle

25.2.2- The Nitrogen Cycle

The Nitrogen Cycle is a complex process by which nitrogen circulates between the biotic and abiotic components of the ecosystem. It involves the transformation of atmospheric nitrogen (N_2) into compounds that can be used by living organisms, and the subsequent return of N_2 to the atmosphere.

Tidbit
While the water cycle moves a molecule we can notice, the Nitrogen Cycle deals with an invisible gas that makes up about 78% of our atmosphere.

The Cyclic Path of Nitrogen

The nitrogen cycle moves in a continuous loop, passing through the following five essential steps:

1. Nitrogen Fixation (Entry into the Soil)

The atmosphere is 78% nitrogen gas (N_2). Its atoms are joined by a strong triple bond. Plants cannot break these bonds. Nitrogen fixation is the process of converting N_2 into inorganic compounds like ammonia (NH_3). It is done in three ways;

i. **Biological Fixation:** More than 90% of all nitrogen fixation is done by soil microorganisms. There are two kinds of nitrogen-fixing microorganisms: (i) free-living (non-symbiotic) organisms (e.g., cyanobacteria or blue-green algae, *Azotobacter*, and *Clostridium)* and (ii) mutualistic (symbiotic) bacteria (e.g., *Rhizobium*) present in the root nodules of many pulses (legumes) plants like Chana (Chickpeas) or Moong (Mung beans). These nitrogen-fixing microorganisms "fix" nitrogen directly from the air in the soil and convert it to ammonia.

ii. **Atmospheric Fixation:** During rains and storms, lightning provides the massive energy needed to combine atmospheric nitrogen with oxygen. So, N_2 is converted int nitrogen oxides and then into nitrates. Only a small amount (5-10%) of nitrogen is fixed in this way.

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iii. **Industrial fixation:** The synthesis of nitrogen containing fertilizers is called industrial fixation. In this process, atmospheric nitrogen and hydrogen are combined to produce ammonia.

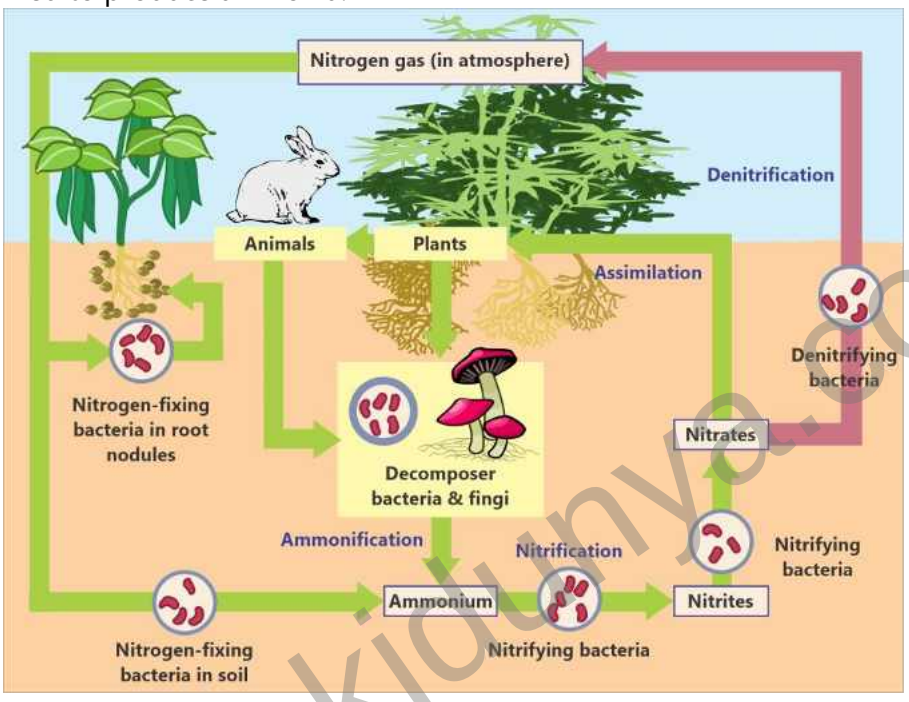

Figure 25.3: The nitrogen cycle

2. Nitrification (Conversion to Plant Food)

Ammonia is often toxic or difficult for plants to use in large amounts. Soil bacteria (such as *Nitrosomonas* and *Nitrobacter*) act as converters. *Nitrosomonas* convert ammonia to nitrite (NO_2^-). *Nitrobacter* convert this nitrite to Nitrate (NO_3^-). Nitrates are easily absorbed by plants.

3. Assimilation (Entry into the Biotic World)

Assimilation is the process in which plants and microbes absorb nitrates from the soil and use them to make proteins, DNA and chlorophyll. Animals assimilate nitrogen by consuming plants and other animals.

4. Ammonification (The Recycling Step)

When plants and animals die, or when animals release nitrogenous waste, **decomposers** (fungi and bacteria) break down the complex proteins. They convert the organic nitrogen back into Ammonia.

5. Denitrification (Exit to the Atmosphere)

To keep the cycle balanced, nitrogen must eventually return to the air. In

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waterlogged soils, denitrifying bacteria (e.g., *Pseudomonas* and *Thiobacillus*) convert nitrates back into Nitrogen gas (N_2) which is them released into the atmosphere.

25.3- The Flow of Energy

Along with the matter, energy also flows between the physical environment and organisms. But, unlike the cycling of matter, the flow of energy is unidirectional.

25.3.1- Trophic Levels

In an ecosystem the organisms are arranged in different feeding groups, known as trophic levels.

1. **Trophic level 1** consists of green plants, algae and photosynthetic bacteria. These are the primary producers of an ecosystem.
2. **Trophic level 2** consists of primary consumers (herbivores) which feed directly on the producers e.g., insects, rabbit.
3. **Trophic level 3** consists of secondary consumers (carnivores) and the parasites of animals which feed on the herbivores e.g., frog, snake.
4. **Trophic level 4** consists of tertiary consumers (animals that eat carnivores) e.g., wolf, hawk.
5. **Decomposers and detritivores** (crabs, vultures, and jackals) make a separate trophic level. They feed on all trophic levels. They consume detritus (dead, decomposing plant and animal material), and fecal matter.

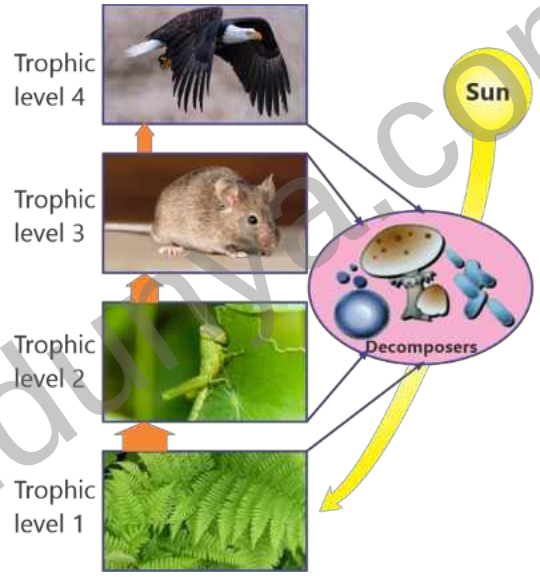

Figure 25.4: Trophic levels

25.3.2- The Loss of Energy between Trophic Levels

There are generally three or four trophic levels in an ecosystem. About 1 to 2% of the solar energy that falls on a first trophic level i.e., producers is converted to the bond-energy of organic matter. During the flow of energy to the next trophic levels, only about 10% is transferred to the next trophic level. Energy is lost at each trophic

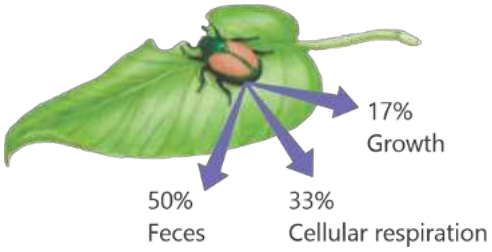

Figure 25.5: Utilization of energy by a heterotroph

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level. In this way, very little usable energy remains in the system after it has been used and incorporated into the bodies of organisms at different trophic levels.

For example, if producers fix 10,000 kcal energy by photosynthesis, the primary consumers would get only 1,000 kcal of it. Of these, about 100 kcal are incorporated into the bodies of secondary consumers. If tertiary consumers eat secondary consumers, they gain about 10 kcal of the 10,000 kcal that originally entered the system.

Tidbit

Short food chains (with a smaller number of trophic levels) are more energy efficient than long food chains (with more trophic levels). This is because, energy is lost as heat during energy transfer at each trophic level. So, efficiency is higher when fewer steps are involved in the food chains.

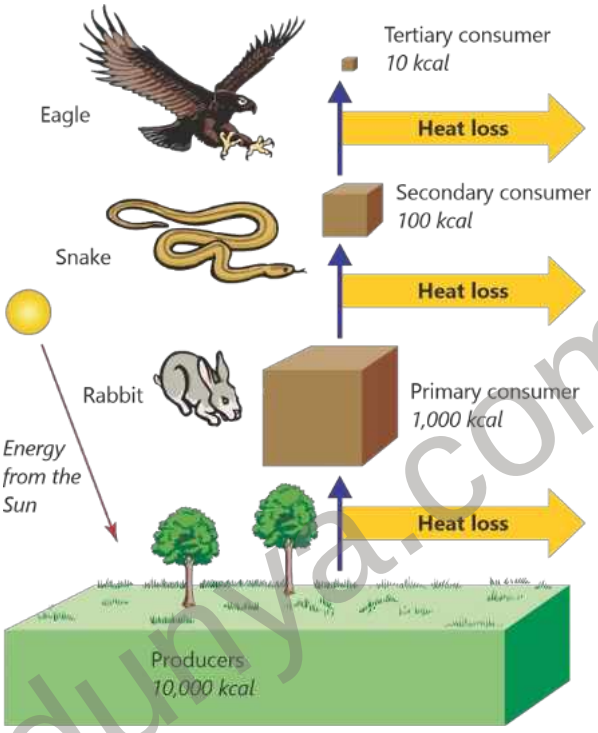

Figure 25.6: Energy flow in trophic levels

25.4- Characteristics of Population

Demography is the statistical study of the characteristics of populations. Population size is the most important features of demography because it is directly related to the ability of a given population to survive.

1- Population Survivorship

Population survivorship is the percentage of members of a group that are alive at a given age. It is often visualized via survivorship curves in survivorship graphs. In such graphs, the Y-axis shows the numbers of survivors, and the X-axis mentions age. Such graphs make three kinds of survivorship curves.

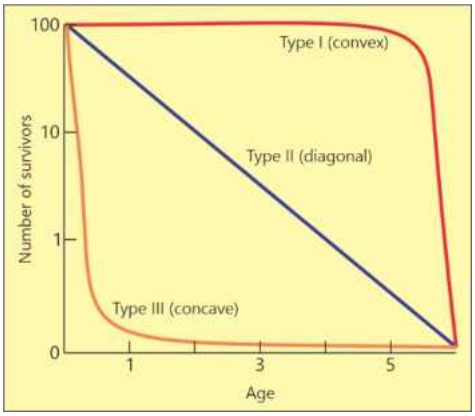

Figure 25.7: Survivorship curves

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1. **Type 1 (convex) populations:** In such populations, individuals survive to an old age, then die rapidly. Environmental factors have very less impact on mortality

most individuals live their potential life span. Humans' and mammals' populations make type I survivorship.

1. **Type II (diagonal) populations:** In such populations, individuals have a constant probability of death throughout their lives. The environment has an important influence on death and is no harsher on the young than on the old. Populations of birds, lizards, and rodents exhibit type II survivorship curves.
2. **Type III (concave) populations:** In such populations, individuals experience very high juvenile mortality rates. Those reaching adulthood, however, have a much lower mortality rate. Fishes and many invertebrates display type III survivorship curves.

2- Population Growth

The Increase in the number of individuals within over a specific time period is called population growth. It is an important attribute of populations. There are two population growth models.

Exponential growth model: According to this model, the population grows without limits at its maximal rate. Rather than increasing by adding a constant number of individuals to the population in every generation, the population increases by the same ratio per unit time. Not all populations display exponential growth.

Logistic growth model: In this model, the growing population eventually reaches a limit due to shortage of resources like space, light, water, or nutrients. Such population stabilizes at a certain size, called the carrying capacity of the particular place where it lives. In these situations, growth curves assume a sigmoid, or flattened S, shape.

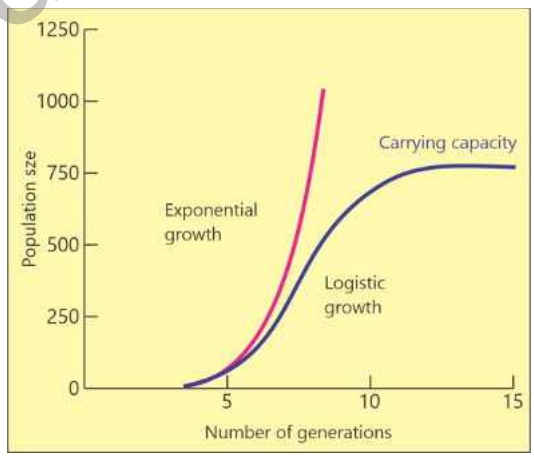

Figure 25.8: Population growth models

3- Population Density

Population density is the number of individuals per unit area or volume. e.g., the number of mulberry trees per square kilometer in Muzaffarabad or the number of *E. coli* bacteria per milliliter in a test tube. In populations with high density, when populations approach their carrying capacity, competition for resources can be severe,

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leading to decreased birth rate and increased risk of mortality. High population densities can also result in high rates of pollution.

4- Population Dispersion or Distribution

Another key characteristic of population structure is the way in which individuals of a population are dispersed or distributed within the population.

1- Random spacing: In random spacing, the individuals within populations do not interact strongly with one another. It is not common in nature. For example, it occurs in some plants that have wind-dispersed seeds that germinate wherever they fall in a favorable environment.

2- Uniform spacing: In some populations, individuals are uniformly distributed. For example, some plant species inhibit the growth of nearby individuals, leading to a uniform distance between each plant. Similarly, animals that maintain defined territories, such as nesting penguins, also exhibit uniform dispersion.

3- Clumped spacing: In some populations, individuals clump into groups or clusters due to uneven distribution of resources. Clumped spacing is common in nature because individual animals, plants, and microorganisms tend to prefer resourceful habitats. Clumped spacing is seen in plants that drop their seeds straight to the ground, or animals that live in groups.

5- Population Carrying Capacity

The carrying capacity is the maximum number of individuals of a particular species that a specific environment can support sustainably over a long period. Carrying capacity is determined by "limiting factors" such as the availability of food, water, shelter, and nesting sites, as well as the presence of predators and diseases.

6- Minimal Viable Population Size

The minimal viable population size is the smallest number of individuals required for a population to survive and persist in the ecosystem. If a population falls below this critical size, it faces a high risk of extinction. In a very small population (like the few remaining Himalayan Brown Bears in Pakistan) inbreeding occurs. This leads to genetic weaknesses and a lower immunity against diseases. Moreover, a single natural disaster (e.g., flood or forest fire) may wipe out a population that is below its minimal viable size.

Day of Eight Billion

While it took 12 years for the global population to grow from 7 to 8 billion. In 2022, it reached 8 billion. Now, it will take about 15 years (until 2037) to reach 9 billion. By 2050, the global population will reach nearly 10 billion, with the vast majority still residing in developing regions.

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25.4.1- Rapid Growth of Human Populations

Starting in the early 1700s, changes in technology have given humans more control over their food supply, enabled them to develop superior weapons to ward off predators, and led to the development of remedies against many diseases. At the same time, humans have become less vulnerable to climatic uncertainties. These changes allowed humans to expand the carrying capacity of their habitats.

About 16% (1.28 billion) of the world's population lives in developed countries, while the remaining 84% (6.72 billion) reside in developing countries. According to the Pakistan Bureau of Statistics, the last census in 2023 recorded Pakistan's population to be 241.49 million. Pakistan's population growth rate is officially recorded at 2.55% annually.

For Information
According to the UNO, the population of Pakistan has now crossed 250 million. Pakistan maintains its rank as the 5th most populous country in the world.

Effect on Ecosystem

The rapidly growing human population is perhaps the greatest challenge to the future of the biosphere. It is placing severe strains on the global environment. The following are some of these impacts:

- Habitat destruction and changes in land use
- Depletion of natural resources (freshwater, fossil fuels etc.)
- Poverty and inflation
- Increased waste generation and elevated pollution
- Climate change
- Deforestation and loss of biodiversity
- Increased chances of new epidemics and pandemics, starvation and malnutrition

For Information
If you weigh all life on Earth, the human population only makes up about 0.01% of the biomass on Earth. About 82% of the Earth's biomass is made by plants while bacteria make about 13% of the biomass.

For Information
The wealthiest 20% of the world's population consumes 86% of the world's resources and produces 53% of the world's carbon dioxide emissions. Whereas, the poorest 20% of the world consumes only 1.3% resources and emits only 3% of CO_2.

25.5- Greenhouse Effect

Greenhous effect is the natural process where gases present in Earth's atmosphere trap the heat radiated from Earth's surface. The gases are called Greenhouse Gases (GHGs). These gases allow sunlight to pass through while prevent heat from escaping directly back into space. So, they keep the Earth warm enough to sustain life.

There has been a marked increase in the concentrations of GHGs, particularly CO_2. It is mainly due to activities in which fossil fuels are used for running machinery,

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driving vehicles, heating homes and generating electricity. The enhanced, unnatural warming of Earth's atmosphere caused by excessive GHGs is the major negative impact of human activities on our environment.

Major Greenhouse Gases

Important greenhouse gases include:

1. **Carbon Dioxide (CO_2):** It is the most significant GHG. It is released through burning fossil fuels (coal, oil, and gas) and deforestation. It contributes about 80% of global warming.

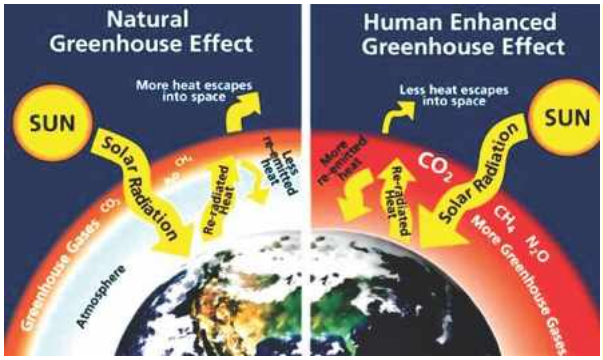

Figure 25.9: Natural and enhanced greenhouse effect (a cause of global warming)

Tidbits

According to the World Meteorological Organization (WMO), before industrialization (1900) the global atmospheric CO_2 concentration was about 280 parts per million (ppm). It has elevated to 428 ppm in 2026 and continues to rise.

The actual mean global temperature has increased about 1°C since 1900, a change known as global warming.

2. **Methane (CH_4):** It is produced during the production of coal and gas, and by livestock (enteric fermentation in cattle) and agricultural practices. It contributes about 11% of global warming.
3. **Nitrous Oxide (N_2O):** It is emitted during agricultural and industrial activities, and during combustion of fossil fuels. It contributes about 6% of global warming.
4. **Fluorinated Gases (Chlorofluorocarbons):** These are synthetic gases emitted from industrial processes (like old refrigerators and air conditioners). These gases contribute about 3% of global warming.

Harmful Effects of Greenhouse Gases

1- **Global Warming:** The intensified greenhouse effect due to emission of excessive GHGs primarily causes global warming. It refers to the long-term increase in the Earth's average surface temperature due to human activities. According to the Intergovernmental Panel on Climate Change (IPCC) Report (2023), global surface temperature has increased by roughly 1.1°C as compared to the pre-industrial era (1850–1900).

Tidbits

For Pakistan, which contributes less than 1% of global GHG emissions but is ranked among the top 10 most vulnerable countries to the devastating effects of climate change.

2- **Heatwaves:** Global warming has turned cities like Jacobabad and Sibi into some of the hottest places on Earth. When atmospheric temperature crosses 50°C, the

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human body cannot adjust normal body temperature, leading to fatal heatstroke. Livestock also experiences heat stress. Winters become shorter and warmer allowing pests and mosquitoes to survive longer. Moreover, heat can worsen the draught conditions. The hot, dry weather increases the risks of wild fires.

3- **Floods:** A warmer atmosphere holds more moisture, leading to erratic and intense rainfall. This leads to erratic and "turbo-charged" monsoons and floods. The floods cause significant damage to forests, homes, and agriculture. They also cause long term damage such as soil erosion, nutrient depletion, and contamination of water resources. Floods also lead to rapid pathogen growth and spread of water-borne diseases.

Figure 25.10: The floods in parts of Pakistan in 2022

Tidbits

In June 2025, intense rains in Pakistan caused worst floods. These floods causes over 1,000 deaths, displacement of over 3 million people, destruction of over 200,000 homes, widespread agricultural and infrastructure losses across all provinces and Gilgit Baltistan. This disaster was due to heavy pre-monsoon rains, glacial-lake outburst floods, and cloudbursts.

4- **Glacial Melting:** Elevated greenhouse effect causes melting of glaciers. Pakistan has more glaciers than anywhere outside the polar regions. Rising temperatures cause these glaciers (like Baltoro and Batura) to melt rapidly. This leads to **Glacial Lake Outburst Floods**. In 2025, several such bursts occurred in Gilgit-Baltistan and Chitral, destroying bridges and entire villages. In the long run, once the glaciers vanish, the Indus River—the lifeline of our agriculture—could run dry.

Tidbits

A **Glacial Lake Outburst Flood** (GLOF) is a sudden release of water from a glacial lake due to the breaking of its natural dam (e.g., ice).

The water of GLOF can travel over 100 km from its source, affecting areas far downstream.

A **cloudburst** is a sudden and extremely heavy rainfall in a short period over a small area.

5- **Sea Level Rise and Coastal Erosion:** As polar ice melts and seawater expands due to heat, sea levels rise. For example, the coastal areas in Thatta and Badin are threatened, where seawater intrusion is already turning fertile agricultural land into salty marshes.

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6- **Food Insecurity:** High temperatures during the flowering stage of Wheat and Rice can significantly reduce grain yield. Similarly, intense heat evaporates soil moisture, turning fertile lands into deserts (Desertification).

7- **Ecosystem Disruption:** Rapid shifts in temperature and rainfall patterns cause serious threats to biodiversity. Such disruptions force the species for changing their habitats or migrate. It further leads to species threatening and even extinction.

25.6- Important Ecosystems of Pakistan

Pakistan's geography ranges from the highest peaks in the north to the Arabian Sea in the south. It creates a "miniature world" of ecological diversity. The following are the four most significant ecosystems of Pakistan.

25.6.1- Temperate Deciduous Forest

These forests are found in the moist mountain regions where there are distinct seasons, including a cold winter that causes trees to drop their leaves (deciduous).

- **Location:** Northern areas including **Shogran, Neelam Valley, Murree,** and parts of **Kaghan**.
- **Abiotic Profile: Soil:** Rich, grayish-brown soil with high organic matter (humus).
- **Climate:** Moderate temperatures (4°C to 30°C); annual rainfall between **750 mm and 1500 mm**.
- **Key Flora:** *Taxus baccata* (Yew), *Pinus wallichiana* (Blue Pine), *Cedrus deodara* (Himalayan Cedar), and shrubs like *Berberis lyceum* (Sumbal).
- **Key Fauna:** Rhesus monkey (*Macaca mulatta*), Black bear, Leopard cat, wolves and various bird species.
- **Current Status: Degraded.** Many large predators have been wiped out, and the forest is under pressure from the lumber industry and agricultural expansion.

Figure 25.11: A temperate deciduous forest with representative flora and fauna

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25.6.2- Tropical Thorn Forest

This is the most widespread terrestrial ecosystem of the plains in Pakistan. It is characterized by xerophytic (drought-resistant) plants with thorns to deter herbivores and reduce water loss.

- **Location:** The Indus Plains, covering much of **Punjab** (Bahawalpur, Khanewal, Mianwali, Dera Ghazi Khan), **Sindh** (southern regions bordering the Indus River), and **Balochistan** (western regions).
- **Abiotic Profile: Climate:** Arid to semi-arid; summer temperatures can reach **50°C**.
- **Water:** Scanty rainfall (200 mm to 750 mm annually).
- **Key Flora:** *Prosopis cineraria* (Jhand/Kandi), *Salvadora oleoides* (Peelu/Wan), and *Capparis aphylla* (Karir) and *Vachellia nilotica* (Kikar).
- **Key Fauna:** Camels, houbara bustard, chinkara, golden jackal, Balochistan gerbil, porcupines, and rattlesnakes.
- **Current Status: Heavily Degraded.** Most of these "natural jungles" have been cleared for human settlements and the massive canal-irrigation agriculture of the Punjab.

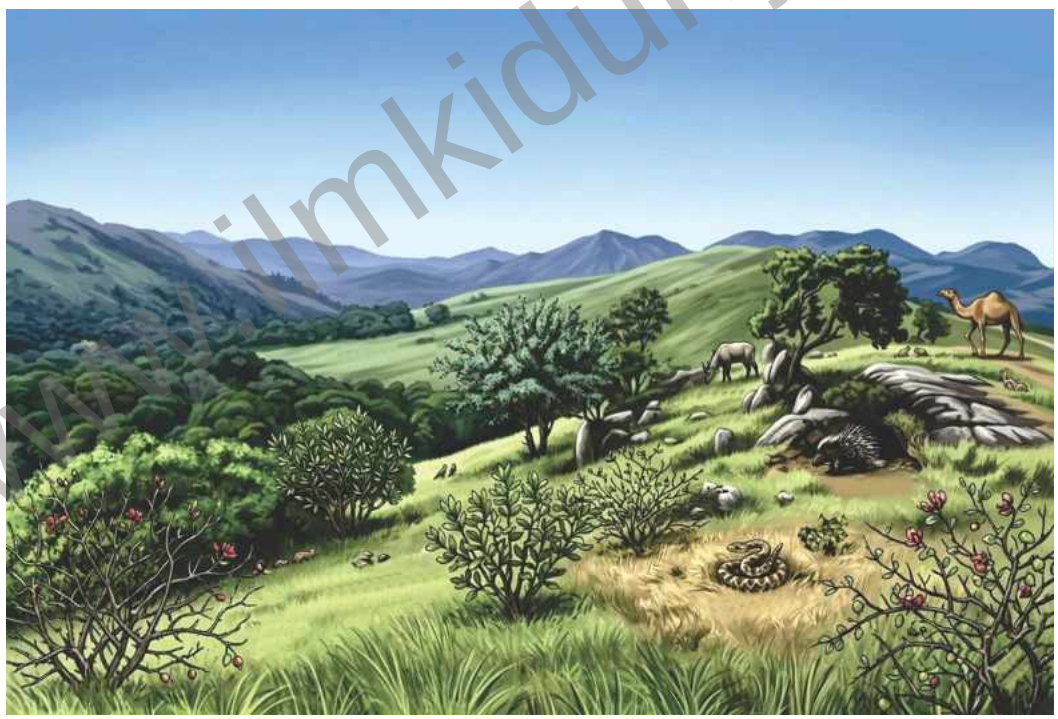

Figure 25.12: A tropical thorn forest with representative flora and fauna

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25.6.3- Alpine and Sub-Alpine Meadows

These are high-altitude "cold deserts" or grasslands, where the climate is too harsh for large trees to grow.

- **Location:** Mountain tops of Gilgit-Baltistan, Chitral, Swat, Azad Jammu & Kashmir, and the Deosai Plains.
- **Abiotic Profile: Temperature:** Severe cold; mean annual temperature between 1°C and 10°C. **Water:** Precipitation mostly in the form of heavy snow (up to 6 feet).
- **Key Flora:** Stunted Junipers, Birch (*Betula utilis*), willow, and various alpine grasses and wildflowers.
- **Key Fauna:** Snow leopard, Himalayan brown bear, Himalayan Ibex, musk deer and Marmots. Birds like snowcock, monal, golden eagle are also found here.
- **Current Status: Fragile.** These areas are highly sensitive to Global Warming, as melting snow caps alter the delicate balance of the meadow.

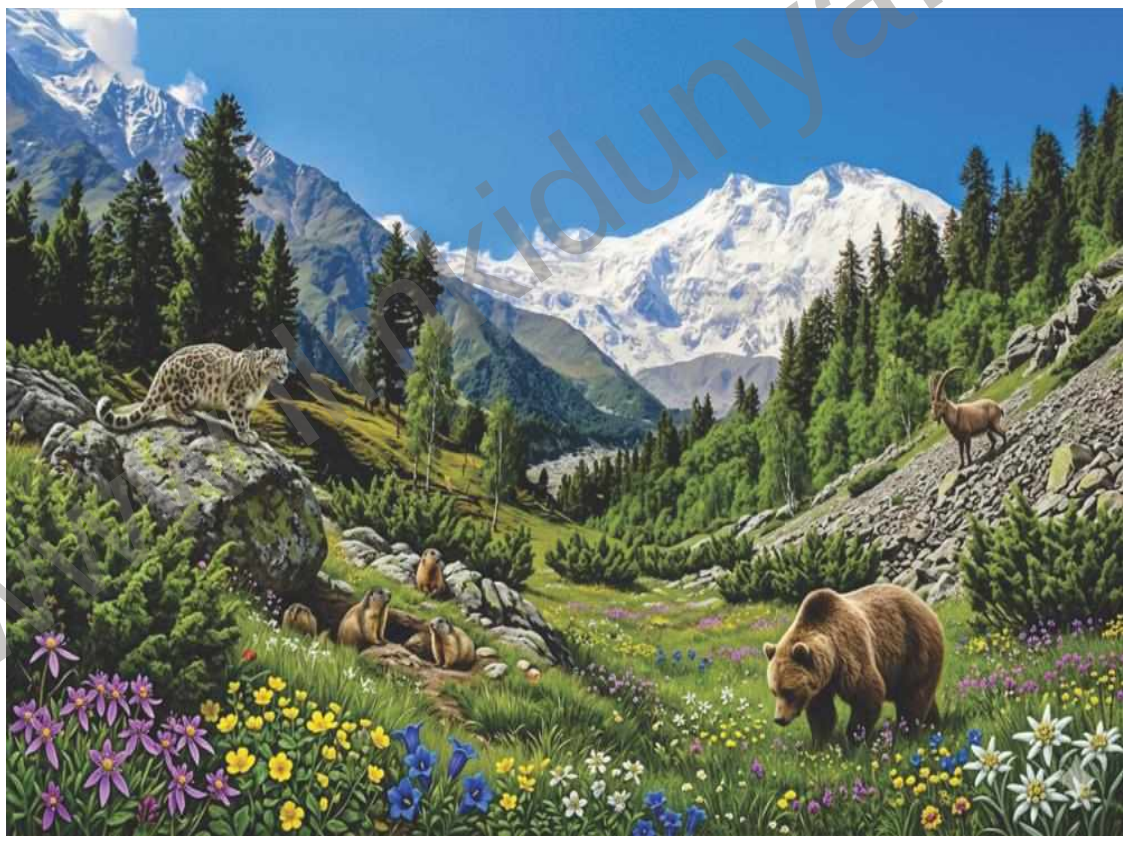

Figure 25.13: An alpine Meadows with representative flora and fauna

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25.6.4- Mangrove Forest (Coastal Ecosystem)

Often called "The Forests of the Sea" these are salt-tolerant forests located at the interface of land and sea.

- **Location:** Sindh (Keti Bandar and Mirpur Sakro mangroves in Indus River Delta) and along the Balochistan coast (Miani Hor, Kalmat Khor, Jiwani & Gawatar Bay).
- **Abiotic Profile: Water:** Brackish (a mix of fresh river water and salty seawater). **Soil:** Anaerobic (oxygen-poor) mudflats; trees have "breathing roots").
- **Key Flora:** Avicennia marina (Timmar) makes up 95% of the forest.
- **Key Fauna:** Crocodiles, shrimps, mudskippers, crabs, lobsters, turtle, snakes, dolphins and birds like flamingo, crane, pelican.
- **Current Status: Threatened** by a reduction in freshwater flow from the Indus and pollution from Karachi, though recent restoration projects have helped save the area.

Figure 25.14: A mangrove forest with representative flora and fauna

EXERCISE

SECTION 1: MULTIPLE CHOICE QUESTIONS

35. If you study the interaction between a herd of Markhors, the grass they eat, and the snow leopards that hunt them, which level of ecological organization are you focusing on?

    (a) Species (b) Population (c) Community (d) Biosphere

36. Nitrogen-fixers are present in the group/s;

(a) Bacteria and fungi
(b) Bacteria only
(c) Fungi only
(d) Bacteria, fungi and viruses

37. In an ecosystem, the energy flow is;
(a) Always unidirectional
(b) Always bidirectional
(c) Non-directional
(d) Cyclic

38. Absorption and re-emission of heat radiation by the atmosphere is called;
(a) Global warming
(c) Ozone depletion
(c) Acid rain
(d) Greenhouse effect

39. A population's carrying capacity.
(a) Can be accurately calculated
(b) Generally, remains constant over time
(c) May change as environmental conditions change
(d) Can never be exceeded

40. During energy flow in ecosystems, how much of the energy at a trophic level enters the next level?
(a) 100% (b) 50% (c) 25% (d) 10%

41. Which group of bacteria is involved in nitrification?
(a) *Azotobacter*
(b) *Nitrosomonas*
(c) *Clostridium*
(d) *Rhizobium*

42. Which step of nitrogen cycle is accomplished by *Pseudomonas*?
(a) Ammonification
(b) Nitrification
(c) Nitrogen fixation
(d) De-nitrification

43. How do nitrogen-fixing bacteria contribute to the nitrogen cycle?
(a) Return nitrogen (N_2) to the atmosphere
`(b) Change ammonium to nitrate
(c) Change N_2 to ammonium
(b) Absorb nitrate from the soil

44. According to 2025-2026 climate data, the "Enhanced Greenhouse Effect" is considered as climate injustice for Pakistan because;
(a) Pakistan produces the majority of global greenhouse gases.
(b) Greenhouse Effect only occurs in South Asia.
(c) Pakistan emits less than 1% of global GHGs but suffers extreme warming and floods.
(d) Industrialized nations have successfully stopped all carbon emissions.

SECTION 2: SHORT QUESTIONS

1. What are the primary reservoirs of the chemicals of biogeochemical cycles?
2. Write notes on de-nitrification and ammonification.
3. Briefly describe the role of bacteria in the nitrogen cycle. Enlist their names and roles.

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4. Write a brief note on the flow of energy in trophic levels.
5. Write brief notes on population density and population growth.
6. Investigate the effects of human population growth on the environment.
7. How does the increased greenhouses gases in atmosphere result in global warming?
8. What are the long-term effects of global warming?
9. Describe the unique adaptations of flora in the Mangrove ecosystem.
10. Distinguish between the Abiotic profiles of a Temperate Deciduous Forest and a Tropical Thorn Forest.
11. Enlist the key fauna and flora of temperate deciduous forests, tropical rain forest, and mangrove forest.
12. Differentiate between:
    - Biome and biosphere
    - Biogeochemcial cycle and energy flow
    - Population growth and population density
    - Convex population and concave population
    - Nitrification and nitrogen-fixation
    - Nitrification and denitrification

SECTION 3: LONG QUESTIONS

31. What is a biogeochemical cycle? Describe water cycle in detail.
32. Describe nitrogen cycle in detail.
33. Explain the flow of energy in successive trophic levels.
34. Explain the problems related to the rapid growth of human populations and the effects of that growth on ecosystem.
35. Describe the causes and impacts of the increasing concentration of greenhouse gases in the atmosphere.
36. Provide a comprehensive account of the Tropical Thorn Forest of Pakistan. Give its location, key flora and fauna, and its current ecological state.
37. Write a detailed note on the Temperate Deciduous Forest in Pakistan.

INQUISITIVE QUESTIONS

18. Justify the fact that humans are responsible for climate change.
19. Investigate the effects of human population growth on ecosystem.
20. Justify why science education has become necessary for everyone to understand the steps man has to take to save the biosphere.
21. Investigate the careers related to the study of environmental resources.
22. **Activity:** Search internet and collect the pictures of the key fauna and flora of different ecosystems in Pakistan.

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Biology Paper Pattern and Pairing Scheme
(12th Class) (New 2026-27)

Total marks = 85
The paper is divided into two main sections:
Objective and Subjective.
Time Allowed: 3 Hours

1. Objective Part (MCQs)
Total Marks: 17
Total MCQs: 17
Time Allowed: 20 Minutes

Q.1 MCQs

Marks breakdown

Chapter No:	Chapter Name	No. of MCQs
CHAPTER# 13	(Thermoregulation and osmoregulation)	1 MCQ
CHAPTER# 14	(Human Urinary System)	1 MCQ
CHAPTER# 15	(Human Nervous System)	2 MCQs
CHAPTER# 16	(Human Endocrine System)	1 MCQ
CHAPTER# 17	(Human Reproductive Systems)	1 MCQ
CHAPTER# 18	(Inheritance)	2 MCQs
CHAPTER# 19	(Chromosomes and DNA)	2 MCQs
CHAPTER# 20	(Biotechnology)	2 MCQs
CHAPTER# 21	(Immunity)	1 MCQ
CHAPTER# 22	(Biostatistics)	1 MCQ
CHAPTER# 23	(Pharmacology)	1 MCQ
CHAPTER# 24	(Evolution)	1 MCQ
CHAPTER# 25	(Ecology)	1 MCQ

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2. Subjective Part
Total Marks: 68
Time Allowed: 2 hours and 40 Minutes

Marks breakdown

Section I: Short Questions (44 Marks)

Q. 2:(Short Questions): Attempt any 8 out of 12 (Chapters: **13,14, 19, 20**) **2X8=16**

CHAPTER # 13	Short Questions: 3
CHAPTER # 14	Short Questions: 3
CHAPTER # 19	Short Questions: 3
CHAPTER # 20	Short Questions: 3

Q. 3: (Short Questions): Attempt any 8 out of 12 (Chapters: **15, 16, 17, 18, 24**) **2X8=16**

CHAPTER # 15	Short Questions: 2
CHAPTER # 16	Short Questions: 2
CHAPTER # 17	Short Questions: 2
CHAPTER # 18	Short Questions: 4
CHAPTER # 24	Short Questions: 2

Q. 4: (Short Questions): Attempt any 6 out of 9 (Chapters: **21, 22, 23, 25**) **2X6=12**

CHAPTER # 21	Short Questions: 2
CHAPTER # 22	Short Questions: 2
CHAPTER # 23	Short Questions: 3
CHAPTER # 25	Short Questions: 2

Section II: Long Questions (24 Marks)

Attempt any 3 questions out of 5.
Each question consists of two parts: (a) 4 marks and (b) 4 marks.

Q.5: Chapter 13 & 25
Q.6: Chapter 14 & 24
Q.7: Chapter 15 & 21
Q.8: Chapter 16 & 20
Q.9: Chapter 17 & 19

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MODEL PAPER OF BIOLOGY FOR CLASS-12

Objective Type

Biology **Time Allowed: 20 min.**

Paper: I (Objective Type) **Maximum Marks: 17**

Q.1. Four possible answers A, B, C and D to each question are given. The choice which you think is correct; fill that circle in front of that question with marker or ink pen in the answer book. Cutting or filling two or more circles will result in zero mark in that question. **[17 × 1 = 17]**

	QUESTIONS	(A)	(B)	(C)	(D)
1	Positive feedback loops are less common because they:	Are slow	Destabilize the system	Use no effectors	Never stop
2	Efferent arterioles of juxtamedullary nephrons give rise to:	Peritubular venules	Afferent arterioles	Vasa recta	Interlobular arteries
3	Long-term drug use reduces dopamine receptors on:	Presynaptic neuron	Postsynaptic neuron	Axon terminal	Synaptic vesicles
4	Which disorder is autoimmune in nature?	Alzheimer's disease	Huntington's disease	Multiple sclerosis	Parkinson's disease
5	Glycoprotein hormones are unable to pass through the membrane because they are:	Lipid-soluble	Non-polar	Polar	Steroid
6	LH stimulates:	Sertoli cells	Germ cells	Leydig cells	Epididymis
7	Crossing over may alter expected ratios by:	preventing segregation	creating linkage breaks	increasing dominance	reducing fertilization
8.	A woman is a carrier for haemophilia. What percentage of her sons may inherit the disease?	25%	50%	75%	100%
9	Okazaki fragments are joined by:	Helicase	Ligase	Primase	Gyrase
10	GC hairpin structure mainly functions to:	Start transcription	Stop RNA polymerase	Repair DNA	Translate protein
11	Which vector is specially designed for large DNA fragments?	BAC	tRNA	mRNA	Operon
12	Most reliable method to confirm gene presence is:	Antibiotic test	Blue-white screening	DNA hybridization	Microscopy
13	Why are natural TILs often ineffective against malignant melanoma?	They cannot divide	Tumour suppresses immune response	They lack nuclei	They produce antibodies only
14	Which group in an experiment receives the treatment?	Control group	Dependent group	Experimental group	Independent group

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15	The first step in drugs discovery is;	Lead optimization	Preclinical Testing	Target identification	Hit identification
16	Changes in gene frequency due to migration of individuals are called;	Genetic drift	Mutation	Gene flow	Genetic recombination
17	Which group of bacteria is involved in nitrification?	Azotobacter	Nitrosomonas	Clostridium	Rhizobium

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MODEL PAPER OF BIOLOGY FOR CLASS-12

Subjective Type

Biology

Paper: II (Essay Type)

Time Allowed: 2.40 Hrs.
Maximum Marks: 68

(SECTION – I) **(22 x 2 = 44)**

Q.2. Write short answers to any eight (8) questions. **8X2=16**

i. How do control centers help maintain homeostasis?
ii. What are the physiological adaptations to reduce water loss in terrestrial animals?
iii. Analyze why humans excrete uric acid even though they are not uricotelic.
iv. Differentiate the two types of nephrons.
v. What is glomerular filtration?
vi. How does ADH relate to Diabetes Insipidus?
vii. Why does DNA have a strong affinity for histone proteins?
viii. Evaluate Griffith's hypothesis about the role of the polysaccharide coat in virulence.
ix. What is a pulse-chase experiment?
x. What is meant by a palindromic sequence in restriction sites?
xi. How the vector turns into recombinant vector?
xii. Differentiate between blue colonies and white colonies in blue-white screening.

Q.3. Write short answers to any eight (8) questions. **8X2=16**

i. Define neuroglia. Write its function.
ii. Name any two excitatory neurotransmitters and state where they act.
iii. What are the functions of Luteinizing Hormone (LH)?
iv. What is myxoedema? What are its symptoms?
v. Name the accessory glands of male reproductive system and their functions.
vi. Why do primary oocytes remain inactive for many years in females?
vii. Justify why O-negative individuals are called universal donors and AB-positive individuals are called universal recipients.
viii. Write brief note on Y-linked inheritance in humans.
ix. How can pleiotropy be considered a limitation to the law of independent assortment?
x. What is Se gene? Where it is located?
xi. Differentiate between Natural selection and neutral selection.
xii. State Hardy-Weinberg theorem.

Q.4. Write short answers to any six (6) questions. **6X2=12**

i. How does respiratory tract provide first line defence?
ii. How does the membrane-attack complex (MAC) destroy microbes?
iii. Why is biostatistics important in medical research?
iv. Describe the difference between descriptive and inferential statistics?
v. Differentiate between antiviral and antiretrovirals drugs.
vi. Write a mode of Tetracycline action?
vii. Write any two advantages of monoclonal antibodies.
viii. Write notes on ammonification.
ix. Investigate the effects of human population growth on the environment.

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(SECTION – II)

Note: Attempt any three questions. **(3X8=24)**

Q.5. a) Classify the animals on the bases of the ability to thermoregulate. 4

b) Explain the flow of energy in successive trophic levels. 4

Q.6. a) How are Kidney stones treated? 4

b) Describe the evidences of evolution that come from comparative anatomy. 4

Q.7. a) Explain the events and propagation of action potential. 4

b) How do inflammatory response act as non-specific response to infections? 4

Q.8. a) Describe negative feedback mechanism. 4

b) Explain the steps of polymerase chain reaction (PCR). 4

Q.9. a) Describe the events of a menstrual cycle. 4

b) Explain the experimental work conducted by Griffith that demonstrated that DNA is the hereditary material. 4

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