Chapter 13: Earth as a System: Energy, Matter, and Life

Exercises — Revise, Reflect, Refine

Q1 Choose the most appropriate option to describe the role of biogeochemical cycles in an ecosystem.
(i) To provide food directly to all organisms.
(ii) To recycle essential nutrients between biotic and abiotic components.
(iii) To create new elements for use by living things.
(iv) To remove pollutants and toxins from the organism.

SOLUTION

Biogeochemical cycles (water, carbon, nitrogen, oxygen) move matter continuously between the living (biotic) and non-living (abiotic) parts of an ecosystem.
Option (i) is incorrect — food is produced by organisms (e.g. plants via photosynthesis), not by biogeochemical cycles directly.
Option (iii) is incorrect — elements such as carbon, nitrogen, and oxygen are not created; they already exist and are simply cycled.
Option (iv) is incorrect — removing pollutants is not the defining function of biogeochemical cycles.
Option (ii) correctly captures the core role: these cycles ensure that essential nutrients (C, N, O, water, etc.) are continuously exchanged and recycled between biotic components (plants, animals, microbes) and abiotic components (atmosphere, soil, water), keeping ecosystems functional.

Answer: (ii) To recycle essential nutrients between biotic and abiotic components.

Q2 Which of the following is primarily responsible for warming of the Earth?
(i) Solar radiation is immediately absorbed by carbon dioxide, which then releases it as heat.
(ii) The atmosphere's tiny particles absorb incoming solar radiation, which directly heats the Earth.
(iii) The Earth's surface absorbs solar radiation, which is then re-radiated and trapped by greenhouse gases.
(iv) The Earth's environment is heated only by the solar radiation reflected by the clouds.

SOLUTION

The chapter explains that shortwave solar radiation passes through the atmosphere largely unimpeded and is absorbed by the Earth's surface.
The surface then re-radiates this energy as longwave (infrared) radiation. Greenhouse gases such as CO_2, CH_4, and water vapour trap this outgoing infrared radiation, warming the lower atmosphere — this is the greenhouse effect.
Option (i) is incorrect — CO_2 does not directly absorb incoming solar radiation and immediately re-release it as heat. The absorption happens at the Earth's surface first.
Option (ii) is incorrect — tiny atmospheric particles (aerosols) mostly scatter and reflect incoming solar radiation, which actually has a cooling effect, not a warming one.
Option (iv) is incorrect — clouds reflect solar radiation back to space, which cools the Earth; this reflected energy does not heat the environment.
Option (iii) correctly describes the mechanism: Earth's surface absorbs solar radiation, re-radiates it as infrared, and greenhouse gases trap that infrared radiation, warming the Earth.

Answer: (iii) The Earth's surface absorbs solar radiation, which is then re-radiated and trapped by greenhouse gases.

Q3 Explain how climate change affects the water cycle. Illustrate with examples.

SOLUTION

Climate change raises the average global temperature, which intensifies every stage of the water cycle.
Increased evaporation: Warmer temperatures cause more water to evaporate from oceans, lakes, and land. This leads to a more moisture-laden atmosphere.
Altered precipitation: Greater atmospheric moisture means heavier rainfall in some regions — for example, more intense monsoons and flash floods in parts of India. At the same time, regions that previously received moderate rainfall may experience drought because warmer air also shifts pressure belts and wind patterns.
Melting of cryosphere: Higher temperatures melt glaciers and polar ice (cryosphere). Himalayan glaciers, for instance, are retreating. Initially this raises river flow, but over decades rivers fed by glacial meltwater (like the Ganga-Brahmaputra system) may reduce to seasonal streams.
Rising sea levels: Melted ice adds water to oceans, raising sea levels and

threatening coastal cities such as Mumbai and Chennai with flooding.

Reduced groundwater recharge: Intense bursts of rainfall cause more runoff and less infiltration into the soil, reducing groundwater recharge. This makes agriculture and drinking water access more difficult during dry months.

Disruption of marine cycle: Warmer, more acidic oceans absorb less CO_2 and support fewer phytoplankton, disrupting both the carbon cycle and marine food chains.

In summary, climate change makes the water cycle more extreme — more intense floods and more severe droughts — while also reducing the long-term reliability of fresh-water sources.

Answer: Climate change intensifies the water cycle: higher temperatures increase evaporation, leading to heavier but more erratic rainfall, faster glacial melting (reducing long-term river flow), rising sea levels, and reduced groundwater recharge — making floods and droughts more extreme.

Q4 Describe how albedo affects the Earth's surface temperature and its climate.

SOLUTION

Albedo is the fraction of incoming solar radiation that a surface reflects. It comes from the Latin word meaning 'whiteness'.

High-albedo surfaces (snow: 0.80–0.90; ice: 0.50–0.70) reflect most of the solar energy, absorbing very little, so they remain cold. This is why polar regions and high-altitude glaciers stay frozen.

Low-albedo surfaces (black soil, ocean water) reflect very little solar radiation and absorb most of it, so they heat up more quickly. Dark-coloured roads and bare soil therefore become much warmer than snow-covered ground under the same sunlight.

Effect on local and regional climate: High-albedo surfaces keep surrounding air cool; low-albedo surfaces warm the local air, driving convection, wind, and rainfall patterns. For example, a land area converted from forest (moderate albedo) to bare soil (lower albedo) warms up faster, which can reduce local rainfall.

Feedback loops with climate change: As global warming melts ice and snow, the high-albedo surfaces are replaced by darker ocean water or land. This lowers the overall albedo of Earth, causing more solar energy to be absorbed and accelerating further warming — a positive feedback loop called the ice-albedo feedback.

Urban heat islands are another example: cities with dark roads and buildings have lower albedo than rural forests, making cities several degrees warmer than their surroundings.

Thus, albedo is a crucial control on surface temperature and influences large-scale climate patterns including monsoon strength, sea-ice extent, and the rate of global warming.

Answer: Albedo (the fraction of solar radiation reflected by a surface) directly controls how much solar energy a surface absorbs. High-albedo surfaces (snow, ice) stay cold by reflecting most sunlight; low-albedo surfaces (dark soil, ocean) absorb more and warm up. Melting of snow and ice reduces Earth's albedo, creating a warming feedback that accelerates climate change.

Q5 How are mountain and valley breezes formed? Suppose there are two mountains, one covered with grass and another covered with barren rocks; would the temperature of the two mountain breezes be different? If so, how?

SOLUTION

Formation of mountain (katabatic) and valley (anabatic) breezes:

During the day (valley breeze): Sunlight heats the mountain slopes faster than the valley floor. The warm air above the slopes becomes less dense and rises. Cooler air from the valley flows upward along the slopes to replace it. This upward flow is called a valley breeze (or anabatic wind).

During the night (mountain breeze): After sunset, the mountain slopes lose heat rapidly by radiation and cool faster than the valley air. The dense, cold air on the slopes sinks down into the valley. This downward flow is called a mountain breeze (or katabatic wind). Farmers in Himalayan valleys like Shimla, Manali, and Darjeeling experience these breezes daily.

Would the breezes from grass-covered vs. barren-rock mountains differ?

Yes, the temperatures of the breezes would differ.

Barren rock mountain: Rocks have a lower heat capacity and lower albedo than vegetation. They absorb more solar radiation and heat up more quickly during the day, generating a warmer, stronger valley breeze (anabatic) during the day. At night they also cool faster, producing a colder, denser mountain breeze (katabatic).

Grass-covered mountain: Grass has a higher albedo than bare rock and also loses heat through transpiration (evapotranspiration cools the surface). The slope

heats up more slowly, so the daytime valley breeze is cooler and less vigorous. At night, the cooling is also less extreme because vegetation retains some heat.

Result: The barren-rock mountain produces stronger temperature contrasts — warmer daytime breezes and colder nighttime breezes — compared to the grass-covered mountain.

Answer: Valley breezes form during the day when slopes heat faster than valleys, causing air to rise; mountain breezes form at night when slopes cool faster, causing cold air to sink. A barren-rock mountain heats and cools faster than a grass-covered one (lower albedo, lower heat capacity, no evapotranspiration), so its breezes are warmer by day and colder by night.

Q6 You have witnessed weather phenomena, such as winds, storms, rainfall, etc. Which atmospheric layer is mainly responsible for such phenomena and what is the primary reason for its occurrence?

SOLUTION

The troposphere (0–12 km from Earth's surface) is the atmospheric layer mainly responsible for weather phenomena such as winds, storms, clouds, rainfall, fog, and cyclones.

Primary reason — uneven heating by the Sun:

The Sun heats the Earth's surface unevenly — the equator receives more intense radiation than the poles, and land heats faster than water. The heated surface warms the overlying tropospheric air by conduction and radiation.

Warm air is less dense and rises (convection), creating zones of low pressure. Cooler, denser air from surrounding regions flows in to fill the low-pressure areas, creating winds. The rising warm air cools as it ascends, and the moisture in it condenses to form clouds and precipitation.

The combination of convection, pressure differences, and the Earth's rotation (Coriolis effect) drives the circulation of the troposphere, generating all common weather events.

The layers above (stratosphere, mesosphere, thermosphere) are too far from the surface to be directly heated this way and lack the moisture and convective instability needed for weather formation. In fact, temperature in the stratosphere increases with height (due to ozone absorbing UV), which suppresses convection there.

Answer: The troposphere (0–12 km) is responsible for all common weather phenomena. The primary reason is uneven solar heating of Earth's surface: warm air rises (low pressure), cooler air flows in (wind), rising air cools and condenses (clouds, rain) — driving convection-powered weather systems.

Q7 Explain the processes involved in the nitrogen cycle. How would life on Earth be affected if nitrogen were not cycled?

SOLUTION

The nitrogen cycle moves nitrogen (N_2) from the atmosphere through soil and organisms and back to the atmosphere.

Step 1 — Nitrogen fixation: Atmospheric N_2 (about 78% of air) is chemically inert and cannot be used directly by most organisms. Nitrogen-fixing bacteria such as Rhizobium (in legume root nodules) and Azotobacter (free-living in soil) convert N_2 into ammonia (NH_3) or ammonium ions (NH_4^+). Lightning also fixes small amounts of N_2 into nitrates.

Step 2 — Nitrification: Nitrifying bacteria such as Nitrosomonas convert ammonium (NH_4^+) to nitrite (NO_2^-), and Nitrobacter convert nitrite to nitrate (NO_3^-). Plants absorb nitrogen mainly as nitrate from the soil.

Step 3 — Assimilation: Plants use nitrate to synthesise proteins and nucleic acids (DNA, RNA). Animals obtain nitrogen by eating plants or other animals.

Step 4 — Ammonification: When organisms die, decomposer bacteria and fungi break down nitrogen-containing organic matter (proteins) into ammonium ions — returning nitrogen to the soil.

Step 5 — Denitrification: Denitrifying bacteria such as Pseudomonas convert nitrates back to N_2 gas, which returns to the atmosphere, completing the cycle.

If nitrogen were not cycled:

Nitrogen is essential for making proteins, DNA, RNA, chlorophyll, and enzymes — the building blocks of all life.

Without cycling, the soil would rapidly become depleted of available nitrogen (nitrates and ammonium). Plants would not be able to synthesise proteins or grow properly. Without plant protein, animals would also have no dietary nitrogen source.

Ecosystems would collapse — photosynthesis would decline (chlorophyll needs nitrogen), reducing food production for all consumers. Biodiversity would plummet and most life as we know it could not persist.

Answer: The nitrogen cycle involves fixation (bacteria convert N_2 to NH_3/NO_3^-), nitrification ($NH_4^+ \rightarrow NO_3^-$), assimilation (plants absorb NO_3^- to make proteins), ammonification (decomposers return N to soil as NH_4^+), and denitrification (bacteria return N_2 to atmosphere). Without cycling, soil nitrogen would be exhausted, plants could not make proteins/chlorophyll, and virtually all life would cease.

Q8 What are the impacts of deforestation on the Earth's oxygen and carbon cycles? What are the other consequences of deforestation?

SOLUTION

Impact on the carbon cycle:

Forests are major carbon sinks — trees absorb CO_2 through photosynthesis and store carbon in their biomass. When forests are cleared and burned, all the stored carbon is released back as CO_2 into the atmosphere, raising its concentration.

Fewer trees also means less CO_2 is removed from the atmosphere on a daily basis, further increasing atmospheric CO_2 levels.

This intensifies the greenhouse effect, accelerating global warming.

Impact on the oxygen cycle:

Forests are the primary producers of atmospheric O_2 through photosynthesis. Removing trees directly reduces the rate of O_2 production.

When forest litter and roots decompose after clearing, decomposers consume O_2, reducing the net O_2 available in the local environment.

Though this has less immediate global impact (the atmosphere contains a large reservoir of O_2), local O_2 levels and air quality decline.

Other consequences of deforestation:

Disruption of the water cycle: Trees intercept rainfall, facilitate infiltration, and add moisture through transpiration. Without trees, more water runs off (causing floods), less recharges groundwater, and local rainfall decreases over time.

Soil erosion: Tree roots hold soil together. Without them, topsoil is washed away by rain and blown by wind, degrading land fertility.

Loss of biodiversity: Forests provide habitat for a vast number of species. Deforestation causes habitat loss, threatening or driving to extinction many plant and animal species.

Eutrophication risk: Increased runoff from cleared land carries excess nutrients and sediment into water bodies, causing algal blooms that deplete dissolved oxygen and kill aquatic life.

Climate feedback: Loss of forest cover lowers local albedo, raises surface temperature, weakens cloud formation, and disrupts regional weather patterns.

Answer: Deforestation releases stored carbon (raising atmospheric CO_2) and reduces O_2 production, intensifying the greenhouse effect. Other consequences: disrupted water cycle (more floods, less groundwater), soil erosion, loss of biodiversity, eutrophication of water bodies, and altered local climate.

Q9 Explain with suitable diagram the path that carbon takes to go back to the atmosphere. You may start from plants using CO_2 from the atmosphere.

SOLUTION

Carbon pathway from atmosphere back to atmosphere (the carbon cycle):

1. Photosynthesis (atmosphere → plants): Plants absorb CO_2 from the atmosphere and use sunlight energy to convert it into glucose and other organic compounds. Carbon is now stored in plant biomass.

2. Respiration (plants → atmosphere): Plants themselves release some CO_2 back to the atmosphere through cellular respiration ($C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O +$ energy).

3. Consumption (plants → animals): Animals eat plants and incorporate the carbon into their own bodies (proteins, fats, carbohydrates). Animals also release CO_2 through respiration.

4. Decomposition (dead organisms → soil/atmosphere): When plants and animals die, decomposer bacteria and fungi break down the organic matter. Carbon is released as CO_2 (aerobic decomposition) or CH_4 (anaerobic decomposition), returning to the atmosphere.

5. Combustion (fossil fuels → atmosphere): Over millions of years, dead organic matter buried in the Earth is slowly converted to coal, oil, and natural gas (fossil fuels). When these are burned for energy, the stored carbon is rapidly released as CO_2 — far faster than natural cycles can absorb it.

6. Ocean exchange (atmosphere ↔ ocean): CO_2 dissolves in ocean water and is used by marine organisms to form calcium carbonate shells. When these organisms die, carbon is stored in ocean sediments (slow cycle). CO_2 also re-enters the atmosphere when the ocean surface warms.

Diagram description (Carbon Cycle):

Atmosphere (CO_2) --[photosynthesis]--> Plants --[respiration]--> Atmosphere
Plants --[eaten by]--> Animals --[respiration/death]--> Atmosphere
Dead matter --[decomposition]--> Soil/Atmosphere (CO_2/CH_4)
Dead matter --[buried, millions of years]--> Fossil fuels --[combustion]--> Atmosphere
Atmosphere --[dissolves]--> Ocean --[marine organisms]--> Sediments (carbonate) --[slow release]--> Atmosphere

Answer: Carbon moves from atmosphere → plants (photosynthesis) → animals (eating) → atmosphere via respiration and decomposition. Dead organic matter buried over millions of years forms fossil fuels; combustion returns this carbon rapidly to the atmosphere. Oceans also absorb and re-release CO_2. All pathways eventually return carbon to atmospheric CO_2.

Q10 Why is an excess of CO_2 in the atmosphere considered undesirable even though it is required by plants?

SOLUTION

CO_2 is essential for photosynthesis — plants use it along with water and sunlight to make glucose. In this sense, CO_2 is a vital raw material for life on Earth.
However, CO_2 is also a greenhouse gas. It allows shortwave solar radiation to pass through but absorbs and re-emits the longwave (infrared) radiation emitted by the Earth's surface, trapping heat in the lower atmosphere.
At pre-industrial levels (~280 ppm), this natural greenhouse effect kept the Earth's average temperature about 33°C warmer than it would otherwise be — making it habitable.
The problem: human activities (burning fossil fuels, deforestation, industrial processes) have raised atmospheric CO_2 sharply. As shown by the Keeling curve (Fig. 13.14), CO_2 has increased by about 35% since 1960 — from 315 ppm to 420 ppm today. This extra CO_2 traps additional heat, causing global warming.
Consequences of excess CO_2: rising average temperatures, more frequent extreme weather events (heatwaves, storms, intense monsoons), melting of glaciers and polar ice, rising sea levels threatening coastal cities, ocean acidification ($CO_2 + H_2O \Rightarrow H_2CO_3$, which harms coral reefs and shellfish), and disruption of ecosystems and agriculture.
Although plants benefit from slightly elevated CO_2 in controlled conditions, the associated temperature rise, changed rainfall, and droughts more than offset that

benefit for global crop production.
Therefore, even though plants need CO_2, excess CO_2 destabilises Earth's climate system in ways that are harmful to virtually all life.

Answer: Although CO_2 is required for photosynthesis, excess CO_2 (now ~420 ppm, up ~35% since 1960) intensifies the greenhouse effect, causing global warming. This leads to melting glaciers, rising sea levels, ocean acidification, more extreme weather, and disrupted agriculture — harms that far outweigh the benefit to plants.

Q11 How is heat lost from the surface of the Earth? What is its significance?

SOLUTION

The Earth's surface loses heat through three main mechanisms:

1. Infrared (longwave) radiation: The heated Earth's surface emits infrared radiation upward into the atmosphere. This is the dominant mechanism of heat loss on a clear night. Some is absorbed by greenhouse gases and re-radiated; the rest escapes to space.

2. Convection and conduction: The surface heats the air directly above it by conduction. The warmed air rises (convection), carrying heat into the upper atmosphere. This drives atmospheric circulation, winds, and weather systems.

3. Evaporation (latent heat): A large amount of heat is lost from the surface through evaporation of water from oceans, lakes, and moist land. The energy used to convert liquid water to vapour (latent heat of vaporisation) is carried away into the atmosphere, where it is released when water condenses to form clouds and rain. This is one of the most efficient heat-transfer mechanisms across Earth's surface.

Significance of heat loss from the surface:
Energy balance: Heat loss balances the incoming solar energy, maintaining Earth's average temperature within the range that supports life. Without adequate heat loss, temperatures would rise uncontrollably.
Drives weather and climate: Differential heat loss between land and sea, equator and poles, drives pressure gradients, winds, ocean currents, and the water cycle — all of which shape climate and distribute fresh water across the planet.
Regulates the greenhouse effect: The interplay between heat emission from the surface and absorption by greenhouse gases determines the natural greenhouse effect that keeps Earth habitable at ~15°C average instead of –18°C.

Answer: Heat is lost from Earth's surface by: (1) infrared radiation emitted upward, (2) convection — warm air rising and carrying heat away, and (3) evaporation — latent heat carried by water vapour. This heat loss maintains Earth's energy balance, drives atmospheric circulation and the water cycle, and keeps average temperatures in the life-supporting range.

Q12 If the Earth were a flat disc instead of a sphere, how would the patterns of solar radiation and temperature be different?

SOLUTION

On the actual spherical Earth, solar radiation strikes different latitudes at different angles due to Earth's curvature. At the equator the Sun is nearly overhead, so sunlight strikes perpendicularly — concentrated over a small area and thus very intense. Near the poles the same beam of sunlight is spread over a much larger area at a low angle, delivering far less energy per unit area. This causes the temperature gradient from equator (hot) to poles (cold).

If the Earth were a flat disc facing the Sun directly:
Uniform insolation: Every point on the flat surface would receive sunlight at the same angle (approximately perpendicular). The solar energy per unit area would be the same everywhere on the disc.
No equator-to-pole temperature gradient: Without differential heating, there would be no warm equatorial zone and no cold polar zone.
No pressure belts or planetary winds: Temperature gradients drive the global pressure belts (equatorial low, sub-tropical high, polar high, etc.) and planetary wind systems (trade winds, westerlies, polar easterlies). A uniformly heated disc would not develop these circulation patterns.
No seasons: Earth's seasons arise from its axial tilt combined with its spherical shape. A flat disc would not produce meaningful seasonal variation across most of its surface.
Extreme edge effects: The very edges of the disc would receive sunlight at a glancing angle and be extremely cold, while the centre would be hot.
No ocean currents as we know them: The Coriolis effect and differential heating that drive gyres and thermohaline circulation would be absent.
In summary, a flat Earth would have near-uniform temperature across its face, no wind belts, no seasons (except at edges), and a drastically different — and far less livable — climate.

Answer: On a spherical Earth, solar radiation strikes the equator perpendicularly (intense, hot) and poles at a low angle (spread out, cold), creating the temperature gradient that drives winds, ocean currents, and climate. On a flat disc, all points would receive roughly equal solar energy, so there would be no equator-to-pole temperature gradient, no global wind belts, no seasons, and a near-uniform but climatically simple surface.

Q13 Suppose there is a rise in atmospheric temperature on Earth. How would this affect the cryosphere, hydrosphere and biosphere?

SOLUTION

Effect on the cryosphere:

The cryosphere includes glaciers, ice sheets, permafrost, and polar ice caps. A rise in atmospheric temperature would accelerate the melting of all these ice bodies.

Himalayan and alpine glaciers would retreat faster, reducing long-term river flow for hundreds of millions of people who depend on glacial meltwater.

Arctic and Antarctic sea ice would thin and shrink, lowering Earth's overall albedo and creating a warming feedback loop.

Permafrost (permanently frozen ground in Siberia, Canada, Alaska) would thaw, releasing huge stores of methane (CH_4) — a potent greenhouse gas — further accelerating warming.

Effect on the hydrosphere:

Increased evaporation from oceans and land would put more moisture into the atmosphere, intensifying the water cycle.

Precipitation patterns would shift — some regions would get more intense rainfall and floods, while others would experience prolonged droughts.

Melting glaciers and ice sheets would raise sea levels, threatening coastal regions and small island nations with inundation.

Warmer oceans absorb more CO_2, making them more acidic (ocean acidification). This harms coral reefs, shellfish, and the base of marine food chains.

Warmer sea surface temperatures would fuel more intense tropical cyclones and storms.

Effect on the biosphere:

Many species are adapted to specific temperature ranges. Rising temperatures would force species to migrate to higher altitudes or higher latitudes; those unable

to migrate quickly enough would face extinction.
Coral reefs would bleach and die due to warmer, more acidic oceans.
Agricultural zones would shift, disrupting food security. Tropical diseases (malaria, dengue) could spread to new areas as conditions become warmer.
Forest fires would become more frequent and intense, destroying habitats and releasing stored carbon.
The timing of biological events (flowering, migration, breeding) would be disrupted, breaking ecological relationships between species.

Answer: A rise in atmospheric temperature would: melt glaciers and ice caps (cryosphere — raising sea levels and reducing long-term freshwater supply), intensify the water cycle with more extreme floods and droughts and warm/acidify oceans (hydrosphere), and force species migration or extinction, bleach coral reefs, disrupt agriculture, and spread disease (biosphere).

Q14 Explain how the Earth's atmosphere helps in maintaining a suitable temperature for life to survive on the Earth.

SOLUTION

The atmosphere maintains life-supporting temperatures through two key roles: (a) the greenhouse effect and (b) regulating heat redistribution.

1. The greenhouse effect (warming role):
The Sun emits shortwave (visible and UV) radiation that passes through the atmosphere largely unimpeded and is absorbed by Earth's surface.
The warmed surface re-emits this energy as longwave infrared radiation upward.
Greenhouse gases — CO_2, water vapour (H_2O), methane (CH_4), and others — absorb this outgoing infrared radiation and re-radiate some of it back toward the surface.
This traps heat in the lower atmosphere, keeping Earth's average surface temperature about +15°C instead of the –18°C it would be without any atmosphere. This 33°C of natural warming is what makes liquid water and life possible.

2. The ozone layer (protective role):
The stratosphere (12–50 km) contains the ozone layer, which absorbs most of the Sun's harmful ultraviolet (UV) radiation. Without this shield, UV radiation would destroy DNA, kill surface organisms, and make photosynthesis impossible.

3. Heat redistribution:
The atmosphere transports heat from the hot equatorial regions toward the poles via wind systems and weather patterns. This moderates extreme temperature differences, making a broader range of latitudes habitable.

4. Moderating temperature swings:
The atmosphere (especially its water vapour) acts like a thermal blanket — slowing heat loss at night and preventing extreme cooling. Without an atmosphere, day-night temperature swings would be extreme (like on the Moon: +127°C in the day to –173°C at night).

Together, these roles keep Earth's surface temperature within the narrow range (~0°C to ~50°C across most inhabited regions) in which liquid water exists and biological processes can function.

Answer: The atmosphere maintains suitable temperatures by: (1) the greenhouse effect — greenhouse gases trap outgoing infrared radiation, warming the surface by ~33°C above what it would be without atmosphere; (2) the ozone layer blocking harmful UV; (3) redistributing heat from equator to poles via winds; and (4) acting as a thermal blanket that reduces extreme day-night temperature swings.

Q15 Describe the interrelationship between different spheres of the Earth. Illustrate with example how these spheres function in a delicate balance.

SOLUTION

Earth's four major spheres are: the geosphere (solid Earth — rocks, soil, landforms), the hydrosphere (all water — oceans, rivers, groundwater, ice), the atmosphere (air surrounding Earth), and the biosphere (all living organisms).

How they are interrelated:
The geosphere and hydrosphere interact through the water cycle: water erodes rocks, dissolves minerals, and carries them to the oceans, while volcanic activity (geosphere) releases water vapour into the atmosphere.
The atmosphere and hydrosphere exchange water continuously: evaporation from oceans puts moisture into the atmosphere; precipitation from clouds returns it to the hydrosphere and geosphere.
The biosphere depends on all three abiotic spheres: organisms need air (atmosphere) to breathe, water (hydrosphere) to survive, and soil and minerals (geosphere) for nutrients.

The biosphere also modifies the other spheres: plants absorb CO_2 and release O_2 (atmosphere), roots break down rock (geosphere), and forests regulate evaporation and rainfall (hydrosphere).
The cryosphere (a part of the hydrosphere) affects albedo (how much solar energy Earth reflects), linking it to the atmosphere's temperature.

Example — Delicate balance illustrated through the water-carbon-life cycle:
Oceans absorb CO_2 from the atmosphere (atmosphere-hydrosphere link). Marine phytoplankton use this CO_2 for photosynthesis, producing O_2 and forming the base of the marine food web (hydrosphere-biosphere link).
When phytoplankton die, their carbon-rich bodies sink and are stored in ocean sediments (hydrosphere-geosphere link), sequestering carbon.
If global warming (driven by excess atmospheric CO_2) raises ocean temperatures, phytoplankton productivity declines. This reduces both O_2 production and CO_2 absorption by the ocean. More CO_2 stays in the atmosphere, warming it further — a destabilising feedback.

Another example — Deforestation breaking the balance:
Forests (biosphere) anchor soil (geosphere), regulate water infiltration (hydrosphere), and absorb CO_2 (atmosphere). Clearing forests raises atmospheric CO_2, triggers soil erosion, reduces local rainfall, and causes loss of biodiversity — all four spheres are disrupted simultaneously.

This demonstrates that the spheres are not separate — they are tightly coupled. A disturbance in one sphere ripples through the others. Maintaining ecological balance requires that all spheres function in harmony.

Answer: Earth's geosphere, hydrosphere, atmosphere, and biosphere are tightly interdependent. Example of delicate balance: forests (biosphere) absorb CO_2 (atmosphere), hold soil (geosphere), and regulate water infiltration (hydrosphere). Deforestation simultaneously raises CO_2, erodes soil, reduces rainfall, and collapses biodiversity — showing that disrupting one sphere cascades through all others.