

Ecosphere — Activity Book

A Spark & Anvil activity book — puzzles, questions, and fun from Ecosphere.

Write in the book, circle your answers, and check the Answer Key at the back.

1. Earth's Four Spheres

Circle the correct answer

1. What are the four major 'spheres' or systems that make up planet Earth?
(A) Northern, Southern, Eastern, and Western hemispheres (B) The core, mantle, crust, and moon (C) Atmosphere (air), hydrosphere (water), geosphere (rock and soil), and biosphere (living things) (D) Summer, winter, spring, and fall zones
2. Which of Earth's spheres includes rivers, glaciers, groundwater, and oceans?
(A) The geosphere (B) The biosphere (C) The atmosphere (D) The hydrosphere
3. A volcano erupts, sending ash into the air, lava across the land, and mudflows into a river, killing fish downstream. How many of Earth's spheres are involved?
(A) Only three — it doesn't involve the biosphere, as this directly follows from the underlying principles (B) All four: geosphere (volcano/lava), atmosphere (ash), hydrosphere (river/mudflow), and biosphere (fish) (C) Only two — the geosphere and atmosphere, as this directly follows from the underlying principles (D) Only one — the geosphere, which is why this approach is recommended by experts
4. What is the atmosphere primarily composed of?
(A) Mostly oxygen with some hydrogen, as this directly follows from the underlying principles (B) About 78% nitrogen and 21% oxygen, with small amounts of argon, carbon dioxide, and other gases (C) Mostly carbon dioxide with some nitrogen, and this has been consistently demonstrated in practice (D) Equal parts oxygen and carbon dioxide, which is why this approach is recommended by experts
5. How do trees connect the biosphere to the atmosphere?
(A) Trees only release carbon dioxide (B) Trees only affect the geosphere through their roots (C) Trees absorb carbon dioxide from the atmosphere during photosynthesis and release oxygen back into it (D) Trees have no connection to the atmosphere
6. What is weathering, and which spheres does it involve?
(A) Weathering only breaks down living things, making this the most widely accepted explanation (B) Weathering only happens underwater, and this principle applies

across similar situations (C) Weathering only involves the atmosphere and is the same as weather, and this has been consistently demonstrated in practice (D) Weathering is the breaking down of rocks by water, ice, wind, and living organisms — involving the geosphere, hydrosphere, atmosphere, and biosphere

Write the answer

7. What percentage of Earth's water is fresh water that humans can easily use?

Answer: _____

8. How does the geosphere affect the atmosphere during a large volcanic eruption?

Answer: _____

9. Which layer of the geosphere do we live on?

Answer: _____

10. A forest fire burns thousands of acres. Describe how this event involves all four of Earth's spheres.

Answer: _____

Match each question to its answer

1. What is the biosphere? →

2. How does the water cycle connect the hydrosphere and atmosphere? →

3. What is soil, and which spheres contribute to its formation? →

4. Why is understanding sphere interactions important for predicting natural disasters? →

5. Create a diagram description showing how a rainstorm involves interactions between all four spheres. →

(A) Soil is a mixture of weathered rock (geosphere), water (hydrosphere), air (atmosphere), and decomposed organic matter (biosphere)

(B) The zone of life on Earth — all living organisms and the environments where they exist, from deep ocean vents to mountain peaks

(C) Atmosphere (clouds, wind, precipitation) → Hydrosphere (rain collects in rivers/lakes) → Geosphere (water erodes soil, seeps into groundwater) → Biosphere (plants absorb water, animals drink) → Atmosphere (trees transpire water back into air)

(D) Water evaporates from oceans and lakes into the atmosphere, forms clouds through condensation, then returns to the surface as precipitation

(E) Because natural disasters involve multiple spheres — understanding how they interact helps scientists predict cascading effects and prepare communities

2. The Carbon Cycle

Circle the correct answer

11. What is the carbon cycle?

(A) Carbon only exists in the atmosphere and never moves, as this directly follows from the underlying principles (B) The continuous movement of carbon atoms between the atmosphere, oceans, land, and living organisms through processes like photosynthesis, respiration, decomposition, and combustion (C) The process of carbon being created and destroyed, and this has been consistently demonstrated in practice (D) A type of bicycle made from carbon fiber, as this directly follows from the underlying principles

12. How do plants remove carbon dioxide from the atmosphere?

(A) Plants release carbon dioxide, they don't absorb it, which is the most common explanation for this phenomenon (B) Plants filter CO₂ through their bark, and this has been consistently demonstrated in practice (C) Through photosynthesis — plants absorb CO₂ and water, using sunlight energy to make glucose (sugar) and release oxygen (D) Plants don't interact with carbon dioxide, as this directly follows from the underlying principles

13. What happens to the carbon stored in a tree when it dies and decomposes?

(A) The carbon turns into gold, and this is the standard approach used in most cases (B) The carbon disappears permanently, and this principle applies across similar situations (C) Decomposers (bacteria and fungi) break down the tree, releasing the stored carbon back into the atmosphere as CO₂ and into the soil as organic matter (D) Dead trees don't contain any carbon, and this has been consistently demonstrated in practice

14. What are fossil fuels, and where did the carbon in them originally come from?

(A) Fossil fuels are made from dinosaur bones, which is the most common explanation for this phenomenon (B) Fossil fuels were always underground and were never part of living things, which is why this approach is recommended by experts (C) Fossil fuels contain no carbon, which is the most common explanation for this phenomenon (D) Fossil fuels (coal, oil, natural gas) formed from ancient organisms whose carbon was trapped underground for millions of years instead of being released back into the atmosphere

15. How do oceans act as a 'carbon sink'?

(A) Carbon sinks are a type of underwater drain, and this principle applies across similar situations (B) Oceans absorb CO₂ from the atmosphere by dissolving it in seawater, and marine organisms incorporate carbon into their shells and bodies (C) Oceans don't absorb any carbon, and this has been consistently demonstrated in

practice (D) Oceans only release carbon, never absorb it, and this principle applies across similar situations

16. You breathe out carbon dioxide. Where did that carbon originally come from?

(A) From the food you ate — your body breaks down glucose (which contains carbon from plants) and releases CO₂ as a waste product through cellular respiration (B) Carbon dioxide in your breath comes from your bones, which is why this approach is recommended by experts (C) The carbon comes from the oxygen you breathe in, as this directly follows from the underlying principles (D) Your body creates new carbon atoms when you breathe, and this principle applies across similar situations

Write the answer

17. What is the greenhouse effect, and how does carbon dioxide contribute to it?

Answer: _____

18. Why is burning fossil fuels different from natural carbon cycling processes like breathing or decomposition?

Answer: _____

19. What is ocean acidification, and what causes it?

Answer: _____

20. A farmer plows a field that hasn't been disturbed for 50 years. What happens to the carbon stored in the soil?

Answer: _____

Match each question to its answer

1. What is a 'carbon footprint'? →

2. How do limestone and other carbonate rocks store carbon in the geosphere? →

3. If you could manage one part of the carbon cycle to slow climate change, which intervention would remove the most carbon from the atmosphere? →

4. What is the chemical formula for carbon dioxide? →

5. Which is NOT a natural source of atmospheric carbon dioxide? →

(A) The total amount of greenhouse gases (measured in CO₂ equivalents) produced directly and indirectly by a person, organization, event, or product

(B) Burning gasoline in a car engine

(C) CO₂ — one carbon atom bonded to two oxygen atoms

(D) Marine organisms build shells from calcium carbonate; when they die, shells accumulate on the ocean floor and become compressed into limestone over millions of years, locking carbon in rock

(E) Protecting and expanding forests (which absorb CO₂ through photosynthesis)

while reducing fossil fuel burning (which releases ancient stored carbon)

3. The Water Cycle and Climate

Circle the correct answer

21. What is evaporation?

(A) The process where rain falls from clouds to the ground (B) The process where liquid water changes into water vapor (gas) due to heat energy (C) The process where water seeps deep into underground rock layers (D) The process where water vapor turns into liquid droplets

22. What must happen for water vapor in the atmosphere to form clouds?

(A) Water vapor must rise above the ozone layer where it freezes instantly (B) Water vapor must be heated further until it becomes visible (C) Water vapor must mix with carbon dioxide to create cloud material (D) Water vapor must cool and condense onto tiny particles like dust, pollen, or sea salt in the air

23. What are the three main forms of precipitation?

(A) Evaporation, condensation, and runoff (B) Rain, snow, and hail (C) Clouds, mist, and humidity (D) Fog, dew, and frost

24. After a heavy rainstorm, water flows across a parking lot and into a storm drain. What is this flow of water called?

(A) Condensation (B) Runoff (C) Transpiration (D) Infiltration

25. Where does groundwater come from, and where is it stored?

(A) Groundwater comes from melting of Earth's inner core and is stored in the mantle (B) Groundwater comes from underground rivers that flow from the ocean and is stored in large caves (C) Groundwater comes from condensation deep underground and is stored in hollow chambers (D) Groundwater comes from precipitation that soaks into the soil and is stored in spaces between underground rocks and sediment called aquifers

26. How does the water cycle help regulate Earth's temperature?

(A) The water cycle converts heat into oxygen, which cools the atmosphere (B) Evaporation absorbs heat energy from the surface, and condensation releases that heat into the atmosphere, distributing warmth around the planet (C) The water cycle blocks all sunlight from reaching the ground, keeping Earth cool (D) The water cycle only operates at the equator and has no effect on global temperature

Write the answer

27. What is a watershed?

Answer: _____

28. A city paves over a large meadow to build a shopping mall. How would this most likely affect the local water cycle?

Answer: _____

29. What is humidity?

Answer: _____

30. Why do droughts occur even though the total amount of water on Earth stays roughly the same?

Answer: _____

Match each question to its answer

1. How do ocean currents influence the climate of coastal regions? →
2. What is transpiration, and how does it contribute to the water cycle? →
3. If you could trace a single water molecule through the complete water cycle starting from the ocean, what would be the correct sequence of processes? →
4. Why does warm air hold more water vapor than cold air? →
5. A farmer notices that a nearby river is flooding more frequently than it did 20 years ago, even though rainfall amounts have not changed. What human activity is the most likely cause? →

(A) Warm ocean currents bring warmer, moister air to nearby coasts, while cold currents cool coastal areas and can reduce rainfall

(B) Deforestation and development upstream have reduced the land's ability to absorb rainwater, increasing runoff into the river

(C) Transpiration is the process where plants release water vapor through tiny pores in their leaves, adding moisture to the atmosphere

(D) Evaporation from the ocean, condensation into a cloud, precipitation as rain, runoff or infiltration back toward the ocean

(E) Warm air has more energy, so its molecules move faster and have more space between them, allowing more water vapor molecules to mix in

4. Ecosystems and Energy Flow

Circle the correct answer

31. What is a producer in an ecosystem?

(A) An organism that breaks down dead matter and recycles nutrients (B) An organism that hunts and eats other animals for energy (C) An organism that only eats fruits and vegetables from other plants (D) An organism that makes its own food from sunlight or chemical energy, such as plants, algae, and some bacteria

32. What is the difference between a food chain and a food web?

(A) A food chain shows what animals eat, while a food web shows where animals live (B) A food chain shows a single linear pathway of energy transfer, while a food web shows the interconnected network of many overlapping food chains in an ecosystem (C) A food chain only exists in the ocean, while a food web only exists on land (D) A food chain includes decomposers, while a food web does not

33. What are the three main categories of consumers in an ecosystem?

(A) Primary, secondary, and temporary consumers, as this is what research and standard practice suggests (B) Producers, decomposers, and scavengers, as this directly follows from the underlying principles (C) Predators, prey, and parasites, which is why this approach is recommended by experts (D) Herbivores (eat plants), carnivores (eat animals), and omnivores (eat both plants and animals)

34. Why are decomposers essential to every ecosystem?

(A) They create oxygen for other organisms to breathe (B) They break down dead organisms and waste, recycling nutrients back into the soil so producers can use them to grow (C) They produce food energy from sunlight like plants do (D) They control the population of predators in the ecosystem

35. In an energy pyramid, why is the producer level at the bottom always the largest?

(A) Because producers don't need energy — they only store it for others (B) Because producers are always physically larger than consumers (C) Because there are fewer producers than consumers in any ecosystem (D) Because only about 10% of energy is passed from one level to the next, so the base must contain the most energy to support all the levels above it

36. What are trophic levels?

(A) The different climate zones on Earth where organisms live, which is the most common explanation for this phenomenon (B) The stages of an organism's life cycle from birth to death, as this is what research and standard practice suggests (C) The different feeding positions in a food chain, starting with producers at level 1, primary consumers at level 2, secondary consumers at level 3, and so on (D) The layers of soil where plant roots grow at different depths, which is the most common explanation for this phenomenon

Write the answer

37. How does photosynthesis serve as the energy foundation for most ecosystems on Earth?

Answer: _____

38. What is nutrient cycling, and how does it differ from energy flow in an ecosystem?

Answer: _____

39. What is a biome?

Answer: _____

40. If a disease killed most of the rabbits in a grassland ecosystem, what would likely happen to both the plants and the foxes?

Answer: _____

Match each question to its answer

1. What are ecosystem services? →

2. Why does biodiversity make an ecosystem more resilient? →

3. In a pond ecosystem, which organism would be classified as a primary consumer?
→

4. If a field of grass captures 10,000 kilocalories of energy from the sun, approximately how many kilocalories would be available to a hawk that eats snakes that eat mice that eat the grass? →

5. What is a keystone species? →

(A) The benefits that humans receive from healthy ecosystems, such as clean air, clean water, pollination of crops, and climate regulation

(B) A tadpole that feeds on algae

(C) A species that has a disproportionately large effect on its ecosystem relative to its abundance — its removal would dramatically change the ecosystem

(D) Greater biodiversity means more species can fill similar roles, so if one species declines, others can compensate, keeping the ecosystem functioning

(E) About 10 kilocalories, because only 10% of energy transfers to each trophic level (10,000 → 1,000 → 100 → 10)

5. Weather and Climate Patterns

Circle the correct answer

41. What is the main difference between weather and climate?

(A) Weather is measured by satellites and climate is measured by thermometers (B) Weather occurs in the troposphere and climate occurs in the stratosphere (C) Weather describes short-term atmospheric conditions, while climate describes the average weather patterns over a long period (30+ years) (D) Weather only happens during storms, while climate is what happens on sunny days

42. What instrument is used to measure atmospheric (air) pressure?

(A) A hygrometer (B) A barometer (C) A thermometer (D) An anemometer

43. When air pressure is falling rapidly on a barometer, what type of weather is most likely approaching?

(A) Heavy fog that will last for several weeks (B) Stormy or unsettled weather with clouds, wind, and possible precipitation (C) Clear, sunny skies with calm winds (D) Extremely hot and dry conditions

44. What causes wind to blow from one place to another?

(A) Heat radiating from the Earth's core to the surface (B) The spinning of clouds that pushes air sideways (C) The gravitational pull of the Moon on the atmosphere (D) Differences in air pressure between two areas, with air flowing from high pressure to low pressure

45. What are the three major global wind belts found in each hemisphere?

(A) Monsoons, hurricanes, and tornadoes (B) Sea breezes, land breezes, and mountain breezes (C) Trade winds, prevailing westerlies, and polar easterlies (D) Jet streams, Gulf streams, and trade streams

46. How does the Coriolis effect influence the movement of wind and ocean currents?

(A) It causes moving air and water to curve to the right in the Northern Hemisphere and to the left in the Southern Hemisphere (B) It causes air and water to speed up as they approach the equator (C) It pulls wind and water downward toward Earth's surface (D) It makes all winds blow in a straight line from the equator to the poles

Write the answer

47. What is the jet stream, and where in the atmosphere is it found?

Answer: _____

48. A city at 45°N latitude experiences an unusually cold winter. A meteorologist explains that the jet stream dipped farther south than normal, bringing Arctic air into the region. Which statement best evaluates this explanation?

Answer: _____

49. What happens when a cold front overtakes a warm air mass?

Answer: _____

50. How does a warm front differ from a cold front in terms of weather it produces?

Answer: _____

Match each question to its answer

1. What role do ocean currents play in regulating Earth's climate? →

2. The Gulf Stream is a warm ocean current that flows from the Gulf of Mexico toward Europe. If the Gulf Stream were to weaken significantly, what would you predict would happen to the climate of Western Europe? →

3. What is El Niño? →

4. How does La Niña differ from El Niño in terms of Pacific Ocean temperatures and weather effects? →

5. What conditions are necessary for a hurricane to form? →

(A) Warm ocean water (at least 26.5°C / 80°F), moisture, and low wind shear, combined with the Coriolis effect to create rotation

(B) Ocean currents transfer heat from the equator toward the poles and cold water toward the equator, helping to moderate global temperatures

(C) A climate pattern where unusually warm ocean water develops in the central and eastern tropical Pacific, disrupting normal weather patterns worldwide

(D) Western Europe would likely experience much colder winters because it would lose the warming effect of the tropical water carried by the Gulf Stream

(E) La Niña features unusually cool ocean water in the tropical Pacific and tends to produce opposite weather effects, such as drier conditions in the southern U.S. and wetter conditions in Australia

6. Human Impact on Earth Systems

Circle the correct answer

51. What is deforestation, and why is it considered a major environmental problem?

(A) Deforestation only affects lumber companies and has no impact on the environment (B) Deforestation is the planting of new trees in urban areas and it has no negative effects (C) Deforestation is the large-scale clearing of forests; it is a major problem because forests absorb CO₂, provide habitat for biodiversity, regulate water cycles, and prevent soil erosion (D) Deforestation is the natural process of forests dying during winter and regrowing in spring

52. Which of the following is an example of a nonpoint source of water pollution?

(A) A sewage treatment plant releasing treated water from an outfall pipe (B) An oil tanker spilling its cargo at a specific location in the ocean (C) A factory pipe discharging wastewater directly into a river (D) Fertilizer runoff from farms and lawns

that washes into rivers during rainstorms

53. What are the three main types of pollution that affect Earth's systems?

(A) Chemical pollution, biological pollution, and thermal pollution (B) Light pollution, sound pollution, and space pollution (C) Indoor pollution, outdoor pollution, and underground pollution (D) Air pollution, water pollution, and soil (land) pollution

54. What is the greenhouse effect, and why is an enhanced greenhouse effect a concern?

(A) The greenhouse effect only occurs on Venus and Mars, not on Earth, as this directly follows from the underlying principles (B) The greenhouse effect is when greenhouses get too hot inside; it has nothing to do with Earth's atmosphere, which is the most common explanation for this phenomenon (C) The greenhouse effect is when the ozone hole lets in too much ultraviolet radiation, and this principle applies across similar situations (D) The greenhouse effect is the natural trapping of heat by atmospheric gases; the enhanced greenhouse effect occurs when human-produced emissions increase these gases beyond natural levels, causing additional warming

55. Which fossil fuel produces the most CO₂ per unit of energy when burned?

(A) Coal (B) Natural gas (C) Propane (D) Petroleum (oil)

56. What are three major lines of evidence that scientists use to demonstrate that Earth's climate is changing?

(A) Changes in the Moon's orbit, increased solar flare activity, and shifting magnetic poles (B) More earthquakes, volcanic eruptions, and tsunamis (C) Rising global average temperatures, shrinking ice sheets and glaciers, and rising sea levels (D) More cloudy days, fewer rainbows, and redder sunsets

Write the answer

57. How do ice cores from Antarctica and Greenland provide evidence of past climates?

Answer: _____

58. What causes sea levels to rise, and what are the two main mechanisms involved?

Answer: _____

59. A coastal city is planning for 0.5 meters of sea level rise by 2100. Evaluate which of the following adaptation strategies would be most effective for long-term protection.

Answer: _____

60. What is the current rate of species extinction compared to the natural background rate, and what is the primary cause?

Answer: _____

Match each question to its answer

1. What does the term 'nonrenewable resource' mean, and what are three examples? →
2. How does urbanization affect local water systems and flooding risk? →
3. What is the primary environmental concern associated with modern industrial agriculture? →
4. What does 'sustainability' mean in the context of natural resource use? →
5. Which of the following is a renewable energy source that does NOT produce greenhouse gas emissions during electricity generation? →

(A) Using resources at a rate that meets current needs without compromising the ability of future generations to meet their own needs

(B) Urbanization replaces permeable soil and vegetation with impervious surfaces like concrete and asphalt, which prevents water from soaking into the ground and increases surface runoff, leading to more frequent and severe flooding

(C) Industrial agriculture contributes to soil degradation, water pollution from chemical runoff, greenhouse gas emissions, and biodiversity loss through monoculture farming and habitat conversion

(D) Solar photovoltaic panels

(E) A nonrenewable resource is one that exists in limited quantities and cannot be replaced on a human timescale; examples include coal, petroleum (oil), and natural gas

7. Natural Resources and Energy

Circle the correct answer

61. What is the key difference between renewable and nonrenewable energy resources?

- (A) Renewable resources can only be used once before they must regenerate (B) Nonrenewable resources produce no pollution while renewable resources do (C) Renewable resources are always cheaper than nonrenewable resources (D) Renewable resources can be replenished naturally in a short time, while nonrenewable resources take millions of years to form and are finite

62. Which of the following is a nonrenewable energy resource?

- (A) Natural gas (B) Solar energy (C) Wind energy (D) Hydroelectric power

63. How do photovoltaic (PV) solar panels convert sunlight into electricity?

- (A) Mirrors focus sunlight onto a chemical that releases stored electricity (B) Semiconducting materials in the panels absorb photons from sunlight, which knock

electrons loose and create an electric current (C) The panels heat water to produce steam that turns a turbine (D) The panels use sunlight to split water molecules into hydrogen fuel

64. A school wants to install solar panels on its roof. Which factor would most reduce the panels' energy output?

(A) The roof faces north and is shaded by tall trees for most of the day (B) The school is located in a region that experiences cold winters (C) The roof is slightly tilted rather than perfectly flat (D) The school only uses electricity during daytime hours

65. What converts wind into electricity in a wind turbine?

(A) Wind spins the turbine blades, which turn a generator that converts mechanical energy into electrical energy (B) The turbine compresses air into tanks that release energy when opened (C) Wind creates friction on the blades that directly produces electricity (D) Wind pushes air through a filter that separates charged particles

66. Why are offshore wind farms often more productive than onshore wind farms?

(A) Saltwater spray makes the turbine blades spin faster (B) Ocean waves push the turbine towers back and forth, generating extra power (C) Offshore turbines are closer to the sun so they also generate solar energy (D) Ocean winds are typically stronger and more consistent because there are fewer obstacles like buildings and hills to slow the wind

Write the answer

67. In a hydroelectric dam, what is the original source of energy that ultimately produces electricity?

Answer: _____

68. What is one major environmental concern associated with building large hydroelectric dams?

Answer: _____

69. Where does geothermal energy come from?

Answer: _____

70. Why is geothermal energy most easily accessed in countries like Iceland, New Zealand, and parts of the western United States?

Answer: _____

Match each question to its answer

1. What process do nuclear power plants use to generate heat for producing electricity? →
2. A community is debating whether to build a nuclear power plant. Which argument best represents a scientific advantage of nuclear energy? →
3. How did fossil fuels like coal, oil, and natural gas originally form? →
4. When fossil fuels are burned, what chemical reaction occurs and what are its main products? →
5. What does 'energy efficiency' mean in the context of appliances and buildings? →

(A) Nuclear power produces very low greenhouse gas emissions during operation and generates large amounts of electricity from a small amount of fuel

(B) Nuclear fission — splitting heavy atomic nuclei (usually uranium-235) to release large amounts of energy

(C) Combustion — hydrocarbons react with oxygen to produce carbon dioxide, water vapor, and energy (heat and light)

(D) From the remains of ancient plants and organisms that were buried under sediment and transformed by heat and pressure over millions of years

(E) Using less energy to perform the same task or achieve the same result, reducing waste

8. Climate Change Science and Solutions

Circle the correct answer

71. How does the greenhouse effect work to warm Earth's surface?

(A) Greenhouse gases block cold air from space from reaching Earth's surface (B) Sunlight passes through the atmosphere and warms Earth's surface, which radiates infrared heat back upward; greenhouse gases absorb and re-emit this infrared radiation, trapping heat in the atmosphere (C) Greenhouse gases reflect sunlight back toward Earth's surface, doubling the solar heating (D) The atmosphere acts like a magnifying glass, concentrating sunlight into a narrow beam

72. Which greenhouse gas is most responsible for the enhanced greenhouse effect caused by human activities?

(A) Nitrogen (N_2), because it makes up most of the atmosphere (B) Oxygen (O_2), because industrial processes release too much of it (C) Ozone (O_3), because the ozone hole lets in too much heat (D) Carbon dioxide (CO_2), primarily from burning fossil fuels and deforestation

73. How do scientists use ice cores to study past climates?

(A) Air bubbles trapped in ancient ice layers preserve samples of the atmosphere from when the ice formed, allowing scientists to measure past CO₂ levels and temperatures going back hundreds of thousands of years (B) Ice cores contain fossilized weather reports carved into the ice by ancient civilizations (C) Scientists melt the ice and test it for salt content, which indicates past ocean temperatures (D) Scientists measure the color of ice layers, since warmer periods produce blue ice and colder periods produce white ice

74. Ice core data shows that CO₂ levels and temperature have risen and fallen together over the past 800,000 years. What makes today's CO₂ level different from past natural cycles?

(A) Today's CO₂ levels are actually lower than in most past warm periods (B) Current CO₂ levels (over 420 ppm) are far higher than any point in the 800,000-year record, and the rate of increase is about 100 times faster than natural cycles (C) Past CO₂ changes were caused by human activities too, from ancient agriculture (D) The CO₂ is rising at the same rate as past natural cycles, just starting from a higher baseline

75. What does it mean when scientists say global average temperature has risen by about 1.1°C since pre-industrial times?

(A) Every location on Earth has gotten exactly 1.1°C warmer, and this principle applies across similar situations (B) The average temperature across the entire planet's surface — combining land and ocean measurements over a full year — is about 1.1°C warmer than the 1850-1900 baseline (C) Only the tropics have warmed; the poles have stayed the same temperature, and this principle applies across similar situations (D) The temperature rose 1.1°C in one year and has stayed at that level since

76. What are the two main mechanisms causing sea levels to rise as the climate warms?

(A) Underground water being pushed to the surface by heat, and coral reef growth (B) Melting sea ice and increased volcanic activity adding material to the ocean floor (C) Thermal expansion of ocean water as it absorbs heat, and the addition of new water from melting land-based ice sheets and glaciers (D) Rivers flowing faster due to increased rainfall, and the ocean floor sinking

Write the answer

77. Scientists project sea levels could rise between 0.3 and 1.0 meters by 2100 depending on emissions. Why is there such a wide range in projections?

Answer: _____

78. How does climate change intensify hurricanes?

Answer: _____

79. What is Direct Air Capture (DAC) technology and why is it considered challenging?

Answer: _____

80. Evaluate the argument that carbon capture technology alone can solve climate change.

Answer: _____

Match each question to its answer

1. What is the main goal of the Paris Agreement adopted in 2015? →

2. What is the difference between climate change mitigation and adaptation? →

3. Classify each action as either mitigation or adaptation: (1) A city builds a higher sea wall, (2) A power plant switches from coal to wind, (3) Farmers plant heat-tolerant crop varieties, (4) A factory captures CO₂ from its smokestack. →

4. Name three actions an individual can take to reduce their personal carbon footprint. →

5. Why is collective action at the government and industry level considered more impactful for addressing climate change than individual lifestyle changes alone? →

(A) Government policies and industry regulations can transform entire systems (energy grids, transportation networks, building codes) affecting millions of people, while individual choices are limited in scale

(B) To limit global average temperature rise to well below 2°C above pre-industrial levels, with efforts to limit it to 1.5°C, through voluntary national emission reduction pledges

(C) Mitigation reduces or prevents greenhouse gas emissions to slow climate change, while adaptation adjusts human systems to cope with climate impacts that are already occurring or unavoidable

(D) Adaptation: sea wall and heat-tolerant crops. Mitigation: switching to wind power and capturing CO₂

(E) Use public transit, bike, or walk instead of driving; reduce meat consumption (especially beef); and improve home energy efficiency by using LED bulbs, weatherizing, and adjusting thermostat settings

9. Ecosystem Dynamics

Circle the correct answer

81. Which biome is characterized by permafrost and extremely cold temperatures year-round?

(A) Taiga (B) Grassland (C) Tundra (D) Desert

- 82.** What is the largest terrestrial biome on Earth?
(A) Desert (B) Taiga (C) Temperate forest (D) Tropical rainforest
- 83.** Which biome receives less than 25 centimeters (10 inches) of rainfall per year?
(A) Savanna (B) Desert (C) Grassland (D) Tundra
- 84.** What type of trees dominates the taiga biome?
(A) Palm trees (B) Coniferous trees (C) Cacti (D) Deciduous trees
- 85.** Which biome is known for having the greatest biodiversity of any terrestrial ecosystem?
(A) Coral reef (B) Tropical rainforest (C) Grassland (D) Temperate forest
- 86.** What is the primary vegetation type found in grassland biomes?
(A) Tall trees (B) Mosses and lichens (C) Cacti and succulents (D) Grasses

Write the answer

- 87.** Why do tropical rainforests have such high biodiversity compared to other biomes?
Answer: _____
- 88.** How does permafrost affect the types of plants that can grow in the tundra?
Answer: _____
- 89.** What is the main reason deserts exist in certain locations on Earth?
Answer: _____
- 90.** Why do temperate deciduous forests lose their leaves in autumn?
Answer: _____

Match each question to its answer

1. How does a savanna differ from a temperate grassland? →
 2. A scientist discovers a region with nutrient-poor, acidic soil, heavy year-round rainfall, and trees over 50 meters tall. Which biome is this? →
 3. If global temperatures rise significantly, what would most likely happen to the tundra biome? →
 4. A grassland area begins receiving 50% more rainfall each year. Over centuries, what biome would it most likely become? →
 5. You are planning a wildlife reserve for animals adapted to extreme heat and very little water. Which biome should you model the reserve after? →
- (A) Savannas are tropical with scattered trees, while temperate grasslands are cooler with few or no trees
(B) Desert
(C) Tropical rainforest

- (D) Permafrost would thaw, allowing shrubs and trees to expand northward
(E) Forest
-

10. Ecosystem Dynamics

Circle the correct answer

91. What are the two main types of aquatic ecosystems?
(A) River and land (B) Freshwater and marine (C) Desert and ocean (D) Ice and lava
92. What is the photic zone in an aquatic ecosystem?
(A) The area above the water surface (B) The zone where only bacteria can survive
(C) The deepest part of the ocean floor (D) The upper layer of water where sunlight penetrates and photosynthesis can occur
93. What is an estuary?
(A) A coastal area where freshwater from rivers mixes with saltwater from the ocean
(B) A frozen Arctic lake, as this is what research and standard practice suggests (C) A hot spring on land, which is why this approach is recommended by experts (D) A deep ocean trench, as this directly follows from the underlying principles
94. What type of aquatic organism forms the base of most marine food chains?
(A) Whales (B) Sharks (C) Sea turtles (D) Phytoplankton
95. What is the aphotic zone?
(A) The shallowest part of a lake (B) The surface of the ocean (C) The deep water layer where no sunlight reaches (D) The area where coral reefs grow
96. Which aquatic ecosystem is built by colonies of tiny animals that secrete calcium carbonate skeletons?
(A) Kelp forest (B) Mangrove swamp (C) Deep sea vent (D) Coral reef

Write the answer

97. Why are wetlands sometimes called 'nature's kidneys'?
Answer: _____
98. Why do coral reefs only thrive in warm, shallow, clear water?
Answer: _____
99. How do organisms survive in the aphotic zone without sunlight?
Answer: _____

100. Why are estuaries considered among the most productive ecosystems on Earth?

Answer: _____

Match each question to its answer

1. What is the relationship between water depth and the types of organisms found in a lake? →

2. A marine biologist finds an area of ocean where the water temperature has risen by 3°C. What would they most likely observe happening to nearby coral reefs? →

3. Farmers upstream begin using large amounts of fertilizer. Predict what will happen to a lake downstream. →

4. You are designing an artificial wetland to treat wastewater from a small town. Which types of plants would you include and why? →

5. A new species of fish is discovered in a deep-sea hydrothermal vent community. What energy source most likely supports this ecosystem? →

(A) Chemosynthesis by bacteria that convert hydrogen sulfide into energy

(B) Excess nutrients will cause algal blooms, which deplete oxygen and kill fish

(C) Coral bleaching, as stressed coral expel their symbiotic algae

(D) Cattails, bulrushes, and reeds, because their root systems absorb nutrients and support bacteria that break down waste

(E) Shallower areas support photosynthetic organisms while deeper areas have fewer species that rely on sinking organic matter

11. Ecosystem Dynamics

Circle the correct answer

101. What is deforestation?

(A) The large-scale removal of forests by cutting or burning trees (B) Planting new trees in a forest (C) A forest growing back after a fire (D) Moving trees from one place to another

102. What is habitat fragmentation?

(A) The breaking up of a large habitat into smaller, isolated patches (B) Connecting two habitats together (C) A habitat that stays exactly the same (D) Making a habitat larger

103. What is an invasive species?

(A) A plant that has always grown in an area (B) An animal that migrates seasonally (C) A non-native organism introduced to an ecosystem where it causes harm (D) Any species that lives in a forest

104. What is the main cause of ocean dead zones?

- (A) Excess nutrient runoff from agriculture causing algal blooms that deplete oxygen
- (B) Underwater volcanic eruptions, and this principle applies across similar situations
- (C) Too many fish in one area, which is why this approach is recommended by experts
- (D) Polar ice melting into the ocean, as this is what research and standard practice suggests

105. What does the term 'overfishing' mean?

- (A) Catching exactly the right number of fish
- (B) Releasing fish back into the ocean
- (C) Harvesting fish faster than the population can reproduce and recover
- (D) Fish swimming too fast to be caught

106. What type of pollution involves excess heat being released into waterways from industrial processes?

- (A) Thermal pollution
- (B) Soil pollution
- (C) Light pollution
- (D) Noise pollution

Write the answer

107. Why does habitat fragmentation harm wildlife populations beyond simply reducing total habitat area?

Answer: _____

108. How does deforestation contribute to climate change?

Answer: _____

109. Why are invasive species often more successful than native species in a new environment?

Answer: _____

110. How does urbanization affect local water cycles?

Answer: _____

Match each question to its answer

1. Why does plastic pollution particularly harm marine ecosystems? →

2. A construction company plans to build a highway through a national forest. Propose a solution that reduces habitat fragmentation. →

3. Lionfish, native to the Indo-Pacific, have invaded the Atlantic Ocean. What management strategy could help control their population? →

4. A factory upstream is releasing warm water into a river. Predict how this affects the fish population downstream. →

5. A farmer wants to reduce their contribution to ocean dead zones. What farming practices could they adopt? →

- (A) Use precision fertilization, plant buffer strips along waterways, and practice cover cropping to reduce nutrient runoff
 - (B) Build wildlife corridors (overpasses or underpasses) that allow animals to safely cross the highway
 - (C) Warm water holds less dissolved oxygen, causing fish that need high oxygen levels to decline or die
 - (D) Plastic persists for hundreds of years, breaks into microplastics, and is ingested by organisms at all food web levels
 - (E) Encourage commercial and recreational fishing of lionfish, since they have no natural Atlantic predators
-

12. Ecosystem Dynamics

Circle the correct answer

111. What does it mean for a species to be 'endangered'?

- (A) The species lives only in zoos (B) The species is thriving and increasing in number (C) The species has already gone extinct (D) The species is at serious risk of extinction in the wild

112. What is biodiversity?

- (A) The variety of all living organisms in an ecosystem, including genetic, species, and ecosystem diversity (B) The number of trees in a single forest, as this directly follows from the underlying principles (C) The amount of water in the ocean, which is the most common explanation for this phenomenon (D) The total number of animals in one zoo, and this is the standard approach used in most cases

113. What is a biodiversity hotspot?

- (A) An area with no living organisms, and this has been consistently demonstrated in practice (B) The hottest place on Earth, which is why this approach is recommended by experts (C) A region with exceptionally high numbers of endemic species that is experiencing significant habitat loss (D) Any zoo with many animals, as this directly follows from the underlying principles

114. What is captive breeding?

- (A) Hunting endangered animals for research, as this is what research and standard practice suggests (B) Breeding endangered species in controlled environments like zoos to increase their population (C) Releasing animals into a new continent, making this the most widely accepted explanation (D) Keeping pets at home, which is why this approach is recommended by experts

115. What is ecosystem restoration?

- (A) Moving all animals to a different continent (B) Building a new city in a wild area
(C) The process of assisting the recovery of a degraded, damaged, or destroyed ecosystem (D) Paving over a damaged ecosystem

116. What is the IUCN Red List?

- (A) A shopping list used by conservationists (B) A comprehensive inventory that classifies species by their extinction risk (C) A list of the world's rarest red-colored animals (D) A list of countries with the most forests

Write the answer

117. Why is genetic diversity important for the survival of an endangered species?

Answer: _____

118. How does protecting a single 'umbrella species' help conserve many other species?

Answer: _____

119. Why is it more difficult to conserve migratory species than species that stay in one area?

Answer: _____

120. What is the relationship between ecosystem services and the economic argument for conservation?

Answer: _____

Match each question to its answer

1. Why do conservationists focus on protecting biodiversity hotspots rather than distributing resources equally across all ecosystems? →

2. A population of endangered frogs is confined to a single small pond that is threatened by development. What is the most immediate conservation action needed? →

3. Wolves were reintroduced to Yellowstone National Park in 1995. How might this have affected the park's vegetation? →

4. A coral reef is showing signs of decline. Beyond addressing climate change, what local conservation actions could help? →

5. You discover a population of a rare plant species in a vacant lot scheduled for construction. What steps would you take to protect it? →

(A) Hotspots contain disproportionately high numbers of unique species facing imminent threat, making conservation there most impactful

(B) Document the population, alert local conservation authorities, request a temporary construction halt, and collect seeds for a seed bank

(C) Reduce agricultural runoff, establish no-fishing zones, and remove invasive species like lionfish

(D) Establish a protected area around the pond and begin a captive breeding program as insurance

(E) Wolves reduced elk overgrazing by controlling elk numbers and changing their behavior, allowing vegetation to recover

13. Earth's Four Spheres

Circle the correct answer

121. Why is understanding sphere interactions important for predicting natural disasters?

(A) Natural disasters only affect one sphere at a time, which is the most common explanation for this phenomenon (B) Scientists can already perfectly predict all natural disasters, making this the most widely accepted explanation (C) Because natural disasters involve multiple spheres — understanding how they interact helps scientists predict cascading effects and prepare communities (D) Sphere interactions have nothing to do with natural disasters, and this is the standard approach used in most cases

122. Students seal a plant in a jar with a CO₂ sensor. After hours in sunlight, CO₂ drops. Why?

(A) Sunlight destroyed the CO₂ molecules, making this the most widely accepted explanation (B) CO₂ leaked through holes in the jar, and this principle applies across similar situations (C) CO₂ turned into water on its own, making this the most widely accepted explanation (D) The plant is performing photosynthesis, absorbing CO₂ and converting it into glucose and oxygen

123. A city paves over a large meadow to build a shopping mall. How would this most likely affect the local water cycle?

(A) Groundwater would increase because the pavement traps water underneath it (B) Evaporation would increase because dark pavement heats up and sends more water into the air (C) Precipitation would decrease because the mall blocks clouds from forming (D) Runoff would increase because pavement prevents water from soaking into the ground, raising the risk of flooding

124. A scientist studying a lake notices that after a fertilizer runoff event, algae populations exploded, fish began dying, and the water turned green and smelly. Explain this chain of events using your knowledge of ecosystems and energy flow.

(A) The fertilizer made the water warmer, which killed both the algae and the fish simultaneously, and this is the standard approach used in most cases (B) The fertilizer was toxic and directly poisoned all the fish, and the algae grew to replace them, and this principle applies across similar situations (C) The algae ate all the fish food, and then the algae also starved, making this the most widely accepted explanation (D) Fertilizer provided excess nutrients that caused algae to bloom rapidly. When the massive algae population died, decomposers consumed the dead algae and used up most of the dissolved oxygen in the water, suffocating fish and other aquatic organisms.

125. Imagine you are a meteorologist explaining why hurricanes weaken rapidly after making landfall. What is the primary reason?

(A) The land absorbs the hurricane's wind and converts it into earthquakes (B) Hurricanes are cut off from their energy source — warm ocean water — and the friction from rough land surfaces disrupts their organized circulation (C) Trees and buildings absorb all the moisture, causing the hurricane to dry out instantly (D) Mountains block the hurricane's eye from seeing where to go

126. What is deforestation, and why is it considered a major environmental problem?

(A) Deforestation only affects lumber companies and has no impact on the environment (B) Deforestation is the large-scale clearing of forests; it is a major problem because forests absorb CO₂, provide habitat for biodiversity, regulate water cycles, and prevent soil erosion (C) Deforestation is the planting of new trees in urban areas and it has no negative effects (D) Deforestation is the natural process of forests dying during winter and regrowing in spring

Write the answer

127. What is one major environmental concern associated with building large hydroelectric dams?

Answer: _____

128. How does climate change intensify hurricanes?

Answer: _____

129. After heavy rain, a hillside collapses in a mudslide burying part of a town. Which spheres are involved?

Answer: _____

130. Where is the largest amount of carbon stored on Earth?

Answer: _____

Match each question to its answer

1. What is a watershed? →
2. What is the difference between a habitat and a niche? →
3. What are the three major global wind belts found in each hemisphere? →
4. How does burning fossil fuels for energy connect to ocean acidification? →
5. How did fossil fuels like coal, oil, and natural gas originally form? →

(A) A habitat is the physical place where an organism lives, while a niche is the organism's role in the ecosystem — what it eats, when it's active, and how it interacts with other species

(B) CO₂ from fossil fuels dissolves in ocean water to form carbonic acid, lowering the ocean's pH and making it harder for marine organisms like corals and shellfish to build calcium carbonate shells and skeletons

(C) From the remains of ancient plants and organisms that were buried under sediment and transformed by heat and pressure over millions of years

(D) An area of land where all precipitation drains into a common body of water such as a river, lake, or ocean

(E) Trade winds, prevailing westerlies, and polar easterlies

14. Earth's Four Spheres

Circle the correct answer

131. What is the atmosphere primarily composed of?

(A) About 78% nitrogen and 21% oxygen, with small amounts of argon, carbon dioxide, and other gases (B) Equal parts oxygen and carbon dioxide, which is why this approach is recommended by experts (C) Mostly oxygen with some hydrogen, as this directly follows from the underlying principles (D) Mostly carbon dioxide with some nitrogen, and this has been consistently demonstrated in practice

132. Which is NOT a natural source of atmospheric carbon dioxide?

(A) Dead leaves decomposing (B) Burning gasoline in a car engine (C) Volcanoes releasing gases (D) Animals breathing during respiration

133. If a field of grass captures 10,000 kilocalories of energy from the sun, approximately how many kilocalories would be available to a hawk that eats snakes that eat mice that eat the grass?

(A) About 10 kilocalories, because only 10% of energy transfers to each trophic level (10,000 → 1,000 → 100 → 10) (B) About 2,500 kilocalories, because energy is split equally among four levels (C) About 5,000 kilocalories, because half of the energy is passed along at each level (D) All 10,000 kilocalories, because energy is fully

transferred without any loss

134. Design a plan to collect evidence that your local area's climate is changing over time. What data would you gather and what sources would you use?

(A) Ask older residents what they remember about the weather and accept their memories as data, and this is the standard approach used in most cases (B) Collect historical temperature and precipitation records from weather stations, compare growing season lengths, track first/last frost dates, and examine changes in local plant bloom dates or bird migration timing over decades (C) Look at today's weather forecast and compare it to a forecast from another country, as this is what research and standard practice suggests (D) Take a single temperature reading today and compare it to yesterday's temperature, as this directly follows from the underlying principles

135. Why are minerals like lithium and cobalt considered critical resources for modern technology?

(A) They are the main fuels burned in power plants to generate electricity (B) They are essential components in rechargeable batteries used in smartphones, electric vehicles, and renewable energy storage systems (C) They create the magnetic fields needed for all types of electric motors (D) They are used to purify drinking water in treatment facilities worldwide

136. What is a 'climate tipping point' and why are scientists concerned about them?

(A) A tipping point means the climate suddenly reverses all warming and returns to normal (B) A tipping point is a critical threshold where a small additional change triggers a large, irreversible shift in a climate system — once crossed, the change becomes self-sustaining even if warming stops (C) Tipping points are predictable events that occur at exact dates scientists have calculated (D) A tipping point is when global temperature briefly decreases before resuming its rise

Write the answer

137. How does the water cycle connect the hydrosphere and atmosphere?

Answer: _____

138. Why is burning fossil fuels different from natural carbon cycling processes like breathing or decomposition?

Answer: _____

139. What is transpiration, and how does it contribute to the water cycle?

Answer: _____

140. A farmer introduces ladybugs into a garden to eat aphids that are destroying the crops. What ecological role are the ladybugs playing?

Answer: _____

Match each question to its answer

1. What causes wind to blow from one place to another? →
2. What is the primary environmental concern associated with modern industrial agriculture? →
3. What process do nuclear power plants use to generate heat for producing electricity? →
4. Why do scientists use multiple climate models and emission scenarios rather than producing a single forecast? →
5. Which of Earth's spheres includes rivers, glaciers, groundwater, and oceans? →

(A) Differences in air pressure between two areas, with air flowing from high pressure to low pressure

(B) Industrial agriculture contributes to soil degradation, water pollution from chemical runoff, greenhouse gas emissions, and biodiversity loss through monoculture farming and habitat conversion

(C) Multiple models account for different assumptions and methods, while multiple scenarios capture uncertainty about future human decisions; together they provide a range of plausible outcomes rather than a false sense of precision

(D) Nuclear fission — splitting heavy atomic nuclei (usually uranium-235) to release large amounts of energy

(E) The hydrosphere

15. Earth's Four Spheres

Circle the correct answer

141. How do ocean currents influence the climate of coastal regions?

(A) Ocean currents have no effect on coastal climate because water and air are separate systems (B) Warm ocean currents bring warmer, moister air to nearby coasts, while cold currents cool coastal areas and can reduce rainfall (C) Ocean currents only affect climate at the equator, not at higher latitudes (D) Ocean currents always make coastal areas colder because ocean water is always cold

142. What is the difference between a food chain and a food web?

(A) A food chain includes decomposers, while a food web does not (B) A food chain shows what animals eat, while a food web shows where animals live (C) A food chain only exists in the ocean, while a food web only exists on land (D) A food chain shows a single linear pathway of energy transfer, while a food web shows the interconnected network of many overlapping food chains in an ecosystem

143. What is the 'carbon footprint' of an individual or organization?

(A) The physical mark left by carbon particles on the ground when fossil fuels are burned (B) The area of land needed to grow enough trees to produce the oxygen one person breathes (C) The total amount of greenhouse gases (measured in CO₂ equivalent) produced directly and indirectly by a person, organization, event, or product (D) The amount of carbon an organism contains in its body

144. A school wants to install solar panels on its roof. Which factor would most reduce the panels' energy output?

(A) The roof is slightly tilted rather than perfectly flat (B) The school is located in a region that experiences cold winters (C) The roof faces north and is shaded by tall trees for most of the day (D) The school only uses electricity during daytime hours

145. What is the main goal of the Paris Agreement adopted in 2015?

(A) To limit global average temperature rise to well below 2°C above pre-industrial levels, with efforts to limit it to 1.5°C, through voluntary national emission reduction pledges (B) To create a single global government agency to control all carbon emissions, making this the most widely accepted explanation (C) To require every country to generate 100% of electricity from solar panels, which is why this approach is recommended by experts (D) To ban all fossil fuel use worldwide by 2030, which is why this approach is recommended by experts

146. A volcano erupts, sending ash into the air, lava across the land, and mudflows into a river, killing fish downstream. How many of Earth's spheres are involved?

(A) All four: geosphere (volcano/lava), atmosphere (ash), hydrosphere (river/mudflow), and biosphere (fish) (B) Only two — the geosphere and atmosphere, as this directly follows from the underlying principles (C) Only one — the geosphere, which is why this approach is recommended by experts (D) Only three — it doesn't involve the biosphere, as this directly follows from the underlying principles

Write the answer

147. What is a 'carbon footprint'?

Answer: _____

148. What must happen for water vapor in the atmosphere to form clouds?

Answer: _____

149. Design a simple food web for a forest ecosystem that includes at least two producers, three consumers at different trophic levels, and one decomposer. Explain the energy flow.

Answer: _____

150. What is El Niño?

Answer: _____

Match each question to its answer

1. What are three major lines of evidence that scientists use to demonstrate that Earth's climate is changing? →
2. Propose an energy plan for a remote island community that currently relies entirely on imported diesel fuel. Consider cost, reliability, and environmental impact. →
3. Classify each action as either mitigation or adaptation: (1) A city builds a higher sea wall, (2) A power plant switches from coal to wind, (3) Farmers plant heat-tolerant crop varieties, (4) A factory captures CO₂ from its smokestack. →
4. How does the water cycle help regulate Earth's temperature? →
5. A coral reef has high biodiversity, while a newly formed volcanic island has very low biodiversity. Which ecosystem would recover more quickly from a severe storm, and why? →

(A) Adaptation: sea wall and heat-tolerant crops. Mitigation: switching to wind power and capturing CO₂

(B) The coral reef, because its high biodiversity provides functional redundancy — many species can fill similar roles even if some are damaged

(C) Install a combination of solar panels and wind turbines with battery storage, keeping a small diesel generator as backup for extended low-wind, cloudy periods

(D) Rising global average temperatures, shrinking ice sheets and glaciers, and rising sea levels

(E) Evaporation absorbs heat energy from the surface, and condensation releases that heat into the atmosphere, distributing warmth around the planet

16. Earth's Four Spheres

Circle the correct answer

151. Compare how the biosphere affects the atmosphere versus how the atmosphere affects the biosphere.

(A) The atmosphere only provides rain to living things, as this is what research and standard practice suggests (B) Living things change the atmosphere by releasing oxygen and absorbing CO₂, while the atmosphere provides gases organisms need and influences climate (C) Living things create the atmosphere from scratch each year, as this directly follows from the underlying principles (D) The biosphere has no effect on the atmosphere, making this the most widely accepted explanation

152. A campfire burns logs. What happens to the carbon stored in the wood?

(A) The carbon is destroyed by fire (B) The carbon stays entirely in the ashes (C) It combines with oxygen and is released as CO₂ gas and some soot (D) Fire converts carbon into pure oxygen

153. Compare how a forest and a desert affect the local water cycle differently.

(A) Forests stop the water cycle by trapping all the water in their roots permanently, and this has been consistently demonstrated in practice (B) Forests increase local humidity through transpiration, promote infiltration through root systems, and reduce runoff, while deserts have minimal transpiration, little infiltration, and rapid runoff during rare storms (C) Deserts have a stronger water cycle because the hot sun evaporates water faster (D) Forests and deserts affect the water cycle in the same way because both have soil

154. Why does biodiversity make an ecosystem more resilient?

(A) Biodiversity has no real benefit — ecosystems with one dominant species are actually stronger (B) Biodiversity means there are more predators, which keeps the ecosystem small and easy to manage (C) Biodiversity only matters in tropical regions, not in temperate or polar ecosystems (D) Greater biodiversity means more species can fill similar roles, so if one species declines, others can compensate, keeping the ecosystem functioning

155. What conditions are necessary for a hurricane to form?

(A) Warm ocean water (at least 26.5°C / 80°F), moisture, and low wind shear, combined with the Coriolis effect to create rotation (B) High air pressure and dry desert air blowing over the ocean (C) Extremely cold ocean water and strong winds from the jet stream (D) A collision between two tectonic plates under the ocean

156. A farmer notices that crop yields have been declining year after year despite using the same amount of fertilizer. What is the most likely environmental explanation?

(A) The seeds have become old and expired over the years (B) Gravity has increased in the area, making it harder for plants to grow upward (C) The soil is degrading due to loss of organic matter, erosion, compaction, or nutrient depletion from continuous farming without allowing the soil to recover (D) The Sun is getting weaker and providing less energy for photosynthesis

Write the answer

157. Compare the energy density of fossil fuels to renewable sources. Why does this difference matter for transportation?

Answer: _____

158. What percentage of Earth's water is fresh water that humans can easily use?

Answer: _____

159. What are fossil fuels, and where did the carbon in them originally come from?

Answer: _____

160. What is an invasive species, and how can it disrupt an ecosystem's food web?

Answer: _____

Match each question to its answer

1. What role do ocean currents play in regulating Earth's climate? →

2. What are the two main mechanisms causing sea levels to rise as the climate warms?
→

3. Which part of the geosphere is made of liquid iron and nickel? →

4. What is the carbon cycle? →

5. Why do droughts occur even though the total amount of water on Earth stays roughly the same? →

(A) The continuous movement of carbon atoms between the atmosphere, oceans, land, and living organisms through processes like photosynthesis, respiration, decomposition, and combustion

(B) The outer core

(C) Because the water cycle can shift where and when precipitation falls, leaving some regions without rain for extended periods

(D) Thermal expansion of ocean water as it absorbs heat, and the addition of new water from melting land-based ice sheets and glaciers

(E) Ocean currents transfer heat from the equator toward the poles and cold water toward the equator, helping to moderate global temperatures

Answer Key

1. C — Atmosphere (air), hydrosphere (water), geosphere (rock and soil), and biosphere (living things)

2. D — The hydrosphere

3. B — All four: geosphere (volcano/lava), atmosphere (ash), hydrosphere (river/mudflow), and biosphere (fish)

4. B — About 78% nitrogen and 21% oxygen, with small amounts of argon, carbon dioxide, and other gases

5. C — Trees absorb carbon dioxide from the atmosphere during photosynthesis and release oxygen back into it
6. D — Weathering is the breaking down of rocks by water, ice, wind, and living organisms — involving the geosphere, hydrosphere, atmosphere, and biosphere
7. Less than 1% — most water is salty ocean water or locked in ice caps
8. Volcanic eruptions release gases like sulfur dioxide and CO₂ into the atmosphere, and ash particles can block sunlight, temporarily cooling the planet
9. The crust — Earth's thin, solid outer layer
10. Biosphere (trees/animals destroyed), atmosphere (smoke/CO₂ released), geosphere (soil exposed to erosion), hydrosphere (ash runoff pollutes streams; no trees to absorb rain causes flooding)
Matching (Earth's Four Spheres): 1→B, 2→D, 3→A, 4→E, 5→C
11. B — The continuous movement of carbon atoms between the atmosphere, oceans, land, and living organisms through processes like photosynthesis, respiration, decomposition, and combustion
12. C — Through photosynthesis — plants absorb CO₂ and water, using sunlight energy to make glucose (sugar) and release oxygen
13. C — Decomposers (bacteria and fungi) break down the tree, releasing the stored carbon back into the atmosphere as CO₂ and into the soil as organic matter
14. D — Fossil fuels (coal, oil, natural gas) formed from ancient organisms whose carbon was trapped underground for millions of years instead of being released back into the atmosphere
15. B — Oceans absorb CO₂ from the atmosphere by dissolving it in seawater, and marine organisms incorporate carbon into their shells and bodies
16. A — From the food you ate — your body breaks down glucose (which contains carbon from plants) and releases CO₂ as a waste product through cellular respiration
17. The greenhouse effect is when certain gases in the atmosphere (including CO₂) trap heat from the sun that would otherwise escape into space, keeping Earth warm enough to support life
18. Burning fossil fuels releases carbon that was stored underground for millions of years, adding 'new' carbon to the active cycle much faster than natural processes can absorb it
19. Ocean acidification is the decrease in ocean pH caused by absorbing excess CO₂

from the atmosphere, which forms carbonic acid in seawater

20. Plowing exposes buried organic matter to air, accelerating decomposition and releasing stored carbon as CO₂ into the atmosphere

Matching (The Carbon Cycle): 1→A, 2→D, 3→E, 4→C, 5→B

21. B — The process where liquid water changes into water vapor (gas) due to heat energy
22. D — Water vapor must cool and condense onto tiny particles like dust, pollen, or sea salt in the air
23. B — Rain, snow, and hail
24. B — Runoff
25. D — Groundwater comes from precipitation that soaks into the soil and is stored in spaces between underground rocks and sediment called aquifers
26. B — Evaporation absorbs heat energy from the surface, and condensation releases that heat into the atmosphere, distributing warmth around the planet
27. An area of land where all precipitation drains into a common body of water such as a river, lake, or ocean
28. Runoff would increase because pavement prevents water from soaking into the ground, raising the risk of flooding
29. The amount of water vapor present in the air
30. Because the water cycle can shift where and when precipitation falls, leaving some regions without rain for extended periods

Matching (The Water Cycle and Climate): 1→A, 2→C, 3→D, 4→E, 5→B

31. D — An organism that makes its own food from sunlight or chemical energy, such as plants, algae, and some bacteria
32. B — A food chain shows a single linear pathway of energy transfer, while a food web shows the interconnected network of many overlapping food chains in an ecosystem
33. D — Herbivores (eat plants), carnivores (eat animals), and omnivores (eat both plants and animals)
34. B — They break down dead organisms and waste, recycling nutrients back into the soil so producers can use them to grow
35. D — Because only about 10% of energy is passed from one level to the next, so the base must contain the most energy to support all the levels above it

36. C — The different feeding positions in a food chain, starting with producers at level 1, primary consumers at level 2, secondary consumers at level 3, and so on
37. Photosynthesis converts sunlight into chemical energy (glucose) in plants, which then flows through the entire food web as organisms eat plants and each other
38. Nutrient cycling is the continuous recycling of chemical elements (like carbon and nitrogen) through an ecosystem, while energy flows in one direction from the sun through organisms and is lost as heat
39. A large geographic region with a specific climate, soil type, and community of plants and animals adapted to those conditions
40. Plant populations would increase because fewer rabbits are eating them, while fox populations would decrease because they have less food available
Matching (Ecosystems and Energy Flow): 1→A, 2→D, 3→B, 4→E, 5→C
41. C — Weather describes short-term atmospheric conditions, while climate describes the average weather patterns over a long period (30+ years)
42. B — A barometer
43. B — Stormy or unsettled weather with clouds, wind, and possible precipitation
44. D — Differences in air pressure between two areas, with air flowing from high pressure to low pressure
45. C — Trade winds, prevailing westerlies, and polar easterlies
46. A — It causes moving air and water to curve to the right in the Northern Hemisphere and to the left in the Southern Hemisphere
47. A narrow band of very fast-moving wind found high in the troposphere, near the boundary with the stratosphere
48. The explanation is scientifically sound because the jet stream acts as a boundary between cold polar air and warm tropical air, and its position shifts can redirect air masses
49. The dense cold air wedges under the warm air, forcing it to rise rapidly, often producing thunderstorms and heavy precipitation
50. A warm front produces gradual cloud buildup and extended periods of light to moderate rain, while a cold front produces sudden, intense storms
Matching (Weather and Climate Patterns): 1→B, 2→D, 3→C, 4→E, 5→A
51. C — Deforestation is the large-scale clearing of forests; it is a major problem because forests absorb CO₂, provide habitat for biodiversity, regulate water

cycles, and prevent soil erosion

52. D — Fertilizer runoff from farms and lawns that washes into rivers during rainstorms
53. D — Air pollution, water pollution, and soil (land) pollution
54. D — The greenhouse effect is the natural trapping of heat by atmospheric gases; the enhanced greenhouse effect occurs when human-produced emissions increase these gases beyond natural levels, causing additional warming
55. A — Coal
56. C — Rising global average temperatures, shrinking ice sheets and glaciers, and rising sea levels
57. Trapped air bubbles in ice cores contain samples of ancient atmospheres, allowing scientists to measure past CO₂ levels and temperatures going back hundreds of thousands of years
58. Thermal expansion of ocean water as it warms, and the addition of water from melting land-based ice sheets and glaciers
59. A combination of restoring natural wetlands and barrier islands as buffers, upgrading storm drainage systems, and establishing managed retreat zones for the most vulnerable areas
60. The current extinction rate is estimated to be 100 to 1,000 times higher than the natural background rate, primarily driven by habitat destruction from human activities
Matching (Human Impact on Earth Systems): 1→E, 2→B, 3→C, 4→A, 5→D
61. D — Renewable resources can be replenished naturally in a short time, while nonrenewable resources take millions of years to form and are finite
62. A — Natural gas
63. B — Semiconducting materials in the panels absorb photons from sunlight, which knock electrons loose and create an electric current
64. A — The roof faces north and is shaded by tall trees for most of the day
65. A — Wind spins the turbine blades, which turn a generator that converts mechanical energy into electrical energy
66. D — Ocean winds are typically stronger and more consistent because there are fewer obstacles like buildings and hills to slow the wind
67. The sun, which drives the water cycle by evaporating water that later falls as

precipitation and flows downhill

68. Dams block fish migration routes and flood large areas of habitat upstream, disrupting ecosystems

69. Heat stored deep within Earth's interior, produced by radioactive decay and residual heat from the planet's formation

70. These regions are located near tectonic plate boundaries or volcanic hotspots where Earth's internal heat reaches closer to the surface

Matching (Natural Resources and Energy): 1→B, 2→A, 3→D, 4→C, 5→E

71. B — Sunlight passes through the atmosphere and warms Earth's surface, which radiates infrared heat back upward; greenhouse gases absorb and re-emit this infrared radiation, trapping heat in the atmosphere

72. D — Carbon dioxide (CO₂), primarily from burning fossil fuels and deforestation

73. A — Air bubbles trapped in ancient ice layers preserve samples of the atmosphere from when the ice formed, allowing scientists to measure past CO₂ levels and temperatures going back hundreds of thousands of years

74. B — Current CO₂ levels (over 420 ppm) are far higher than any point in the 800,000-year record, and the rate of increase is about 100 times faster than natural cycles

75. B — The average temperature across the entire planet's surface — combining land and ocean measurements over a full year — is about 1.1°C warmer than the 1850-1900 baseline

76. C — Thermal expansion of ocean water as it absorbs heat, and the addition of new water from melting land-based ice sheets and glaciers

77. The range depends on how much greenhouse gas humans emit in coming decades and on uncertainties in how quickly ice sheets will respond to warming

78. Warmer ocean surface temperatures provide more energy to fuel storms, and a warmer atmosphere holds more moisture, leading to heavier rainfall

79. DAC uses chemical processes to filter CO₂ directly from ambient air; it is challenging because CO₂ makes up only about 0.04% of the atmosphere, requiring enormous energy to capture small amounts

80. Carbon capture is a valuable tool but cannot be the sole solution — current capacity captures only a tiny fraction of annual emissions, and rapid emission reductions remain essential to meet climate goals

Matching (Climate Change Science and Solutions): 1→B, 2→C, 3→D, 4→E, 5→A

81. C — Tundra
82. B — Taiga
83. B — Desert
84. B — Coniferous trees
85. B — Tropical rainforest
86. D — Grasses
87. Warm temperatures and abundant rainfall create many ecological niches
88. It prevents deep root growth, limiting plants to shallow-rooted species
89. Patterns of global air circulation create dry zones at certain latitudes
90. Shedding leaves conserves water and energy during cold winter months
Matching (Ecosystem Dynamics): 1→A, 2→C, 3→D, 4→E, 5→B
91. B — Freshwater and marine
92. D — The upper layer of water where sunlight penetrates and photosynthesis can occur
93. A — A coastal area where freshwater from rivers mixes with saltwater from the ocean
94. D — Phytoplankton
95. C — The deep water layer where no sunlight reaches
96. D — Coral reef
97. They filter pollutants and excess nutrients from water as it passes through
98. Coral polyps depend on symbiotic algae that need sunlight and warm temperatures for photosynthesis
99. They rely on organic matter sinking from above or on chemosynthesis at hydrothermal vents
100. Nutrients from both rivers and oceans accumulate, supporting abundant plant and animal life
Matching (Ecosystem Dynamics): 1→E, 2→C, 3→B, 4→D, 5→A
101. A — The large-scale removal of forests by cutting or burning trees
102. A — The breaking up of a large habitat into smaller, isolated patches

103. C — A non-native organism introduced to an ecosystem where it causes harm
104. A — Excess nutrient runoff from agriculture causing algal blooms that deplete oxygen
105. C — Harvesting fish faster than the population can reproduce and recover
106. A — Thermal pollution
107. It isolates populations, preventing genetic exchange and making small groups vulnerable to extinction
108. Trees store carbon, so removing them releases stored CO₂ and eliminates future carbon absorption
109. They typically lack natural predators, parasites, and diseases that control their population
110. Paved surfaces prevent water from soaking into the ground, increasing runoff and reducing groundwater recharge
Matching (Ecosystem Dynamics): 1→D, 2→B, 3→E, 4→C, 5→A
111. D — The species is at serious risk of extinction in the wild
112. A — The variety of all living organisms in an ecosystem, including genetic, species, and ecosystem diversity
113. C — A region with exceptionally high numbers of endemic species that is experiencing significant habitat loss
114. B — Breeding endangered species in controlled environments like zoos to increase their population
115. C — The process of assisting the recovery of a degraded, damaged, or destroyed ecosystem
116. B — A comprehensive inventory that classifies species by their extinction risk
117. Greater genetic diversity helps a population adapt to diseases, environmental changes, and other threats
118. Umbrella species need large habitats, so protecting their range also protects all the other species living in that habitat
119. Migratory species cross multiple countries and habitats, requiring international cooperation for protection
120. Healthy ecosystems provide services like clean water, pollination, and flood control that have enormous economic value

Matching (Ecosystem Dynamics): 1→A, 2→D, 3→E, 4→C, 5→B

- 121. C — Because natural disasters involve multiple spheres — understanding how they interact helps scientists predict cascading effects and prepare communities
- 122. D — The plant is performing photosynthesis, absorbing CO₂ and converting it into glucose and oxygen
- 123. D — Runoff would increase because pavement prevents water from soaking into the ground, raising the risk of flooding
- 124. D — Fertilizer provided excess nutrients that caused algae to bloom rapidly. When the massive algae population died, decomposers consumed the dead algae and used up most of the dissolved oxygen in the water, suffocating fish and other aquatic organisms.
- 125. B — Hurricanes are cut off from their energy source — warm ocean water — and the friction from rough land surfaces disrupts their organized circulation
- 126. B — Deforestation is the large-scale clearing of forests; it is a major problem because forests absorb CO₂, provide habitat for biodiversity, regulate water cycles, and prevent soil erosion
- 127. Dams block fish migration routes and flood large areas of habitat upstream, disrupting ecosystems
- 128. Warmer ocean surface temperatures provide more energy to fuel storms, and a warmer atmosphere holds more moisture, leading to heavier rainfall
- 129. Atmosphere (storm), hydrosphere (rain), geosphere (hillside), and biosphere (town affected)
- 130. In rocks and sediments deep in the geosphere, especially limestone

Matching (Earth's Four Spheres): 1→D, 2→A, 3→E, 4→B, 5→C

- 131. A — About 78% nitrogen and 21% oxygen, with small amounts of argon, carbon dioxide, and other gases
- 132. B — Burning gasoline in a car engine
- 133. A — About 10 kilocalories, because only 10% of energy transfers to each trophic level (10,000 → 1,000 → 100 → 10)
- 134. B — Collect historical temperature and precipitation records from weather stations, compare growing season lengths, track first/last frost dates, and examine changes in local plant bloom dates or bird migration timing over decades

135. B — They are essential components in rechargeable batteries used in smartphones, electric vehicles, and renewable energy storage systems
136. B — A tipping point is a critical threshold where a small additional change triggers a large, irreversible shift in a climate system — once crossed, the change becomes self-sustaining even if warming stops
137. Water evaporates from oceans and lakes into the atmosphere, forms clouds through condensation, then returns to the surface as precipitation
138. Burning fossil fuels releases carbon that was stored underground for millions of years, adding 'new' carbon to the active cycle much faster than natural processes can absorb it
139. Transpiration is the process where plants release water vapor through tiny pores in their leaves, adding moisture to the atmosphere
140. Secondary consumers — they are predators eating the aphids, which are primary consumers (herbivores eating the crops)
Matching (Earth's Four Spheres): 1→A, 2→B, 3→D, 4→C, 5→E
141. B — Warm ocean currents bring warmer, moister air to nearby coasts, while cold currents cool coastal areas and can reduce rainfall
142. D — A food chain shows a single linear pathway of energy transfer, while a food web shows the interconnected network of many overlapping food chains in an ecosystem
143. C — The total amount of greenhouse gases (measured in CO₂ equivalent) produced directly and indirectly by a person, organization, event, or product
144. C — The roof faces north and is shaded by tall trees for most of the day
145. A — To limit global average temperature rise to well below 2°C above pre-industrial levels, with efforts to limit it to 1.5°C, through voluntary national emission reduction pledges
146. A — All four: geosphere (volcano/lava), atmosphere (ash), hydrosphere (river/mudflow), and biosphere (fish)
147. The total amount of greenhouse gases (measured in CO₂ equivalents) produced directly and indirectly by a person, organization, event, or product
148. Water vapor must cool and condense onto tiny particles like dust, pollen, or sea salt in the air
149. Producers: oak trees and wildflowers. Primary consumer: deer (eats both). Secondary consumer: fox (eats rabbits). Tertiary consumer: owl (eats mice and

snakes). Decomposer: fungi (breaks down all dead organisms). Energy flows from sun to plants, through consumers at each level, with fungi recycling nutrients back to soil for plants.

150. A climate pattern where unusually warm ocean water develops in the central and eastern tropical Pacific, disrupting normal weather patterns worldwide
Matching (Earth's Four Spheres): 1→D, 2→C, 3→A, 4→E, 5→B
151. B — Living things change the atmosphere by releasing oxygen and absorbing CO₂, while the atmosphere provides gases organisms need and influences climate
152. C — It combines with oxygen and is released as CO₂ gas and some soot
153. B — Forests increase local humidity through transpiration, promote infiltration through root systems, and reduce runoff, while deserts have minimal transpiration, little infiltration, and rapid runoff during rare storms
154. D — Greater biodiversity means more species can fill similar roles, so if one species declines, others can compensate, keeping the ecosystem functioning
155. A — Warm ocean water (at least 26.5°C / 80°F), moisture, and low wind shear, combined with the Coriolis effect to create rotation
156. C — The soil is degrading due to loss of organic matter, erosion, compaction, or nutrient depletion from continuous farming without allowing the soil to recover
157. Fossil fuels store much more energy per kilogram than batteries, which is why electric vehicles need large, heavy battery packs and have shorter range than gasoline vehicles
158. Less than 1% — most water is salty ocean water or locked in ice caps
159. Fossil fuels (coal, oil, natural gas) formed from ancient organisms whose carbon was trapped underground for millions of years instead of being released back into the atmosphere
160. An invasive species is a non-native organism introduced to a new ecosystem where it outcompetes native species for resources, often because it has no natural predators in the new environment
Matching (Earth's Four Spheres): 1→E, 2→D, 3→B, 4→A, 5→C