

Climatequest — Activity Book

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

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

1. Climate System Basics & Weather vs Climate

Circle the correct answer

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

(A) Weather is measured by scientists and climate is just a guess (B) Weather only happens in summer and climate happens year-round (C) Weather describes short-term conditions, while climate describes long-term patterns over decades (D) Weather happens outdoors and climate happens indoors

2. Scientists usually study at least how many years of weather data before drawing conclusions about a region's climate?

(A) 30 years (B) 5 years (C) 1 year (D) 100 years

3. Which of these is an example of climate rather than weather?

(A) The Amazon rainforest receives an average of 80 inches of rain per year (B) It's going to rain this afternoon in Miami (C) A thunderstorm just knocked out power downtown (D) Tomorrow's high temperature will be 75°F

4. Earth's climate system is made up of five major components. Which list correctly names all five?

(A) Atmosphere, ocean, mountains, forests, deserts (B) Troposphere, stratosphere, mesosphere, thermosphere, exosphere (C) Atmosphere, hydrosphere, cryosphere, biosphere, lithosphere (D) Air, water, ice, soil, humans

5. A student says: 'It snowed a lot this winter, so global warming can't be real.' What is the problem with this argument?

(A) Snow is caused by pollution, not temperature (B) The student should have checked a weather app first (C) Global warming only affects summer temperatures (D) It confuses short-term weather with long-term climate trends

6. What does the atmosphere do that makes life on Earth possible?

(A) It traps heat from the Sun, keeping Earth warm enough for liquid water (B) It blocks all sunlight from reaching the surface (C) It produces oxygen by splitting water molecules (D) It prevents all rain from falling on land

Write the answer

7. The cryosphere refers to all the frozen water on Earth. Which of these is part of the cryosphere?

Answer: _____

8. How do oceans influence Earth's climate?

Answer: _____

9. A city near the ocean rarely gets very hot or very cold, but a city at the same latitude far from the ocean has very hot summers and very cold winters. What explains this difference?

Answer: _____

10. What instrument do scientists use to measure temperature at weather stations?

Answer: _____

Match each question to its answer

1. Why do scientists measure climate data from many different locations around the world instead of just one? →

2. Which of these factors has the biggest influence on why some places are hotter than others on Earth? →

3. Mount Kilimanjaro is near the equator in Tanzania, but its peak is covered in ice. Why is the top of a tropical mountain cold? →

4. Satellites orbiting Earth help scientists study climate. What is one advantage satellites have over ground-based weather stations? →

5. Earth receives energy from the Sun. What happens to most of the sunlight that reaches Earth's surface? →

(A) Climate varies greatly by region, so global data requires measurements from everywhere

(B) The surface absorbs it and converts it to heat, which is then radiated back toward space

(C) Temperature drops as altitude increases — higher elevations are colder regardless of latitude

(D) Distance from the equator (latitude)

(E) Satellites can observe the entire Earth, including oceans and remote areas with no weather stations

2. The Greenhouse Effect & Carbon Cycle

Circle the correct answer

11. What is the greenhouse effect?

(A) A building made of glass where plants grow (B) The process of sunlight making plants green (C) When the ozone layer blocks ultraviolet light (D) The process where certain gases in Earth's atmosphere trap heat, keeping the planet warm

12. Which of these is the most abundant greenhouse gas released by human activities?

(A) Carbon dioxide (CO₂) (B) Helium (He) (C) Oxygen (O₂) (D) Nitrogen (N₂)

13. Is the natural greenhouse effect good or bad for life on Earth?

(A) Good — without it, Earth would be too cold for liquid water and most life (B) Bad — it causes all natural disasters (C) Bad — it has always caused problems for living things (D) Neither — it has no effect on life at all

14. What is the difference between the natural greenhouse effect and the enhanced greenhouse effect?

(A) There is no difference — they are the same thing (B) The natural effect warms the land; the enhanced effect warms the ocean (C) The natural effect only happens at night; the enhanced effect happens during the day (D) The natural effect keeps Earth warm enough for life; the enhanced effect is the extra warming from human-added greenhouse gases

15. Which of these human activities releases the most carbon dioxide into the atmosphere?

(A) Breathing (B) Burning fossil fuels for electricity and transportation (C) Planting trees, as this directly follows from the underlying principles (D) Swimming in the ocean, which is why this approach is recommended by experts

16. In the carbon cycle, what role do plants play?

(A) They absorb CO₂ from the atmosphere through photosynthesis and store carbon in their bodies (B) They have no connection to carbon at all (C) They convert carbon into oxygen permanently (D) They release CO₂ into the atmosphere at all times

Write the answer

17. What happens to the carbon stored in a tree when it dies and decays?

Answer: _____

18. Fossil fuels like coal and oil formed from ancient organisms buried millions of years ago. Why does burning them today affect the carbon cycle?

Answer: _____

19. The ocean absorbs about 25-30% of the CO₂ that humans release. What happens when the ocean absorbs too much CO₂?

Answer: _____

20. Besides carbon dioxide, name another important greenhouse gas.

Answer: _____

Match each question to its answer

1. Before the Industrial Revolution (around 1750), atmospheric CO₂ was about 280 parts per million (ppm). Today it's about 425 ppm. What does this increase tell us? →

2. A carbon sink is something that absorbs more carbon than it releases. Which of these is Earth's largest carbon sink? →

3. If all the greenhouse gases were suddenly removed from Earth's atmosphere, what would happen? →

4. Deforestation (cutting down forests) affects the carbon cycle in two ways. What are they? →

5. Which step correctly describes how the greenhouse effect works? →

(A) Human activities have increased CO₂ in the atmosphere by about 50% in approximately 275 years

(B) It removes trees that absorb CO₂, AND the cut trees release their stored carbon when burned or decomposed

(C) Earth's average temperature would drop to about -18°C (0°F), freezing most water on the planet

(D) Sunlight passes through the atmosphere → Earth's surface absorbs it and emits heat → greenhouse gases absorb the heat and re-emit it in all directions → Earth stays warm

(E) The ocean

3. Feedback Loops & Earth's Energy Balance

Circle the correct answer

21. In climate science, what is a feedback loop?

(A) A weather pattern that repeats exactly the same way every year, which is why this approach is recommended by experts (B) A process where a change in one part of the climate system triggers further changes that either amplify or reduce the original change (C) A circular road that goes around a mountain, and this principle applies across similar situations (D) A comment a teacher gives you about your homework, and this principle applies across similar situations

22. What is the difference between a positive feedback loop and a negative feedback loop in climate science?

(A) Positive feedbacks only happen in summer and negative feedbacks in winter (B) Positive feedbacks are good and negative feedbacks are bad (C) Positive feedbacks involve temperature and negative feedbacks involve rain (D) A positive feedback amplifies the original change; a negative feedback reduces or counteracts it

23. The ice-albedo feedback is one of the most important climate feedbacks. How does it work?

(A) More ice forms → more sunlight is blocked → Earth cools rapidly → ice covers the planet (B) Ice reflects heat from Earth's core back underground (C) Warming melts ice → darker surfaces are exposed → more sunlight is absorbed → more warming → more ice melts (D) Albedo is a type of bird that lives on ice sheets

24. Albedo is a measure of how much light a surface reflects. Which surface has the highest albedo?

(A) Green forest (reflects about 10-20% of sunlight) (B) Fresh snow (reflects about 80-90% of sunlight) (C) Asphalt road (reflects about 4% of sunlight) (D) Dark ocean water (reflects about 6% of sunlight)

25. Earth's energy balance means that the energy coming in from the Sun roughly equals the energy going out. What happens when greenhouse gases increase?

(A) Less heat escapes to space, so energy in exceeds energy out, and Earth warms until a new balance is reached (B) Energy balance is never disrupted by anything, as this directly follows from the underlying principles (C) The Earth starts spinning faster to generate heat, making this the most widely accepted explanation (D) More energy comes in from the Sun, and this is the standard approach used in most cases

26. The water vapor feedback is the strongest positive feedback in the climate system. Explain how it works.

(A) Water vapor has no effect on temperature (B) Water vapor removes CO₂ from the atmosphere by dissolving it (C) Water vapor cools the Earth by forming clouds that block sunlight (D) CO₂ warms the air → warmer air holds more water vapor → water vapor is a greenhouse gas → more warming → even more water vapor

Write the answer

27. Clouds can act as both a positive AND a negative feedback. How?

Answer: _____

28. The permafrost-carbon feedback involves frozen ground in the Arctic. Classify this as a positive or negative feedback and explain why.

Answer: _____

29. Earth radiates more energy to space from the equator than from the poles. How does the climate system redistribute this energy?

Answer: _____

30. Scientists measure Earth's 'energy imbalance' — the difference between energy absorbed and energy emitted. Currently this is about +1 watt per square meter. What does this positive imbalance mean?

Answer: _____

Match each question to its answer

- 1.** The carbon cycle weathering feedback is a very slow negative feedback that stabilizes Earth's climate over millions of years. How does it work? →
- 2.** If Earth's albedo increased (more sunlight reflected), what would happen to the planet's temperature? →
- 3.** In a thought experiment: a volcanic eruption fills the atmosphere with ash particles that block sunlight for two years. Trace the feedback effects through Earth's climate system. →
- 4.** The ocean absorbs about 93% of the excess heat from global warming. Why is this both helpful and concerning? →
- 5.** Vegetation-climate feedback: As the Arctic warms, shrubs and small trees are growing in areas that were previously tundra. Is this a positive or negative feedback for warming? →

(A) Less sunlight reaches the surface → cooling → more snow and ice form → higher albedo → reflects even more sunlight → additional cooling (ice-albedo feedback in reverse)

(B) Positive — dark green vegetation has lower albedo than light-colored tundra, so it absorbs more sunlight and warms the surface further

(C) Temperature would decrease because less solar energy would be absorbed by the surface

(D) Warmer temperatures increase rain and chemical weathering of rocks, which absorbs CO₂ from the air, gradually reducing warming

(E) Helpful because it slows atmospheric warming, but concerning because it causes ocean warming that harms marine ecosystems and drives sea level rise

4. Ocean Systems & Sea Level Change

Circle the correct answer

31. What percentage of Earth's surface is covered by oceans?

(A) About 50% (B) About 95% (C) About 25% (D) About 71%

32. What are the two main causes of sea level rise?

(A) Ships displacing water and rivers flowing faster (B) The Moon pulling on the ocean and earthquakes (C) Thermal expansion (warming water expands) and melting land ice (glaciers and ice sheets) (D) More rain falling into the ocean and underwater volcanoes

33. Why does melting sea ice (ice floating in the ocean) NOT significantly raise sea levels, while melting land ice does?

(A) Sea ice is made of a different type of water that evaporates when it melts, making this the most widely accepted explanation (B) Sea ice is too small to matter, making this the most widely accepted explanation (C) Land ice melts faster than sea ice, as this is what research and standard practice suggests (D) Sea ice already displaces its weight in water while floating, so melting it doesn't add volume; land ice is new water entering the ocean

34. Ocean currents act like a global conveyor belt. What drives this system of deep ocean circulation?

(A) Giant underwater fans installed by scientists, as this is what research and standard practice suggests (B) Fish swimming in coordinated patterns, and this has been consistently demonstrated in practice (C) Differences in water density caused by temperature and salinity — cold, salty water sinks and warm water rises (D) The rotation of the Moon around Earth, and this has been consistently demonstrated in practice

35. The Gulf Stream is a warm ocean current that flows from the Gulf of Mexico toward Europe. How does it affect Europe's climate?

(A) It only affects fish populations, not weather or climate (B) It has no effect on Europe because it's too far away (C) It cools Europe by bringing cold water from the Arctic (D) It carries warm water northward, keeping Western Europe significantly warmer than other places at the same latitude

36. Scientists are concerned that melting Greenland ice could slow or disrupt the Atlantic Meridional Overturning Circulation (AMOC). Why would freshwater from melting ice affect ocean circulation?

(A) Fresh water contains minerals that block the current (B) Fresh meltwater is less dense than salty seawater, preventing the sinking that drives the conveyor belt circulation (C) Meltwater is too cold and freezes the ocean current (D) Fresh water is heavier than salt water, so it sinks too fast

Write the answer

37. What is ocean acidification?

Answer: _____

38. Coral reefs are sometimes called 'the rainforests of the sea.' How does ocean warming threaten coral reefs?

Answer: _____

39. Thermal expansion means water takes up more space when it warms. If you heated all the water in a swimming pool by 1°C, the level would rise only slightly. Why is thermal expansion a major contributor to sea level rise?

Answer: _____

40. How much has global sea level risen since 1900?

Answer: _____

Match each question to its answer

1. El Niño is a climate pattern where warm water spreads across the tropical Pacific. How does El Niño affect weather around the world? →

2. Miami, Florida is experiencing increased 'sunny day flooding' — flooding during high tides even without rain or storms. What is causing this? →

3. The ocean has absorbed about 90% of the excess heat from global warming. Where in the ocean is most of this heat stored? →

4. If the entire Greenland ice sheet melted, sea levels would rise approximately 7 meters (23 feet). Which of these would be a consequence? →

5. Ocean acidification makes it harder for marine organisms to build shells and skeletons made of calcium carbonate. Which organisms are most threatened? →

(A) Corals, clams, oysters, sea urchins, and tiny plankton called pteropods that form the base of marine food webs

(B) In the upper 700 meters (the top layer), though warming is now penetrating into deeper water

(C) Major coastal cities like New York, Mumbai, Shanghai, and London would be partially or fully submerged

(D) Sea level rise has raised the baseline water level, so normal high tides now reach streets that used to stay dry

(E) It shifts rainfall patterns globally — bringing floods to some regions and droughts to others

5. Paleoclimate: Evidence from the Past

Circle the correct answer

41. What is paleoclimatology?

(A) The study of past climates using natural records preserved in ice, rocks, sediments, tree rings, and fossils (B) The study of dinosaur behavior patterns, and this is the standard approach used in most cases (C) The study of planets in our solar system, which is the most common explanation for this phenomenon (D) The study of ancient human civilizations, which is the most common explanation for this phenomenon

42. Ice cores from Antarctica contain air bubbles trapped when snow compacted into ice. What can scientists learn from these tiny bubbles?

(A) The number of fish in ancient oceans, and this principle applies across similar situations (B) How many people lived on Earth at that time, making this the most widely accepted explanation (C) The composition of the ancient atmosphere — including CO₂ and methane levels going back 800,000 years (D) The color of the sky millions of years ago, and this principle applies across similar situations

43. Tree rings can reveal information about past climate. What does a wide ring typically indicate?

(A) A year with favorable growing conditions — adequate rainfall and warm temperatures (B) A year with extremely cold winters (C) A year when the tree was struck by lightning (D) A year when the tree was sick

44. Scientists use oxygen isotope ratios (¹⁸O/¹⁶O) in ice cores to estimate past temperatures. Heavier oxygen-18 evaporates less easily than lighter oxygen-16. In ice from a very cold period, what would you expect?

(A) No oxygen at all — ice from cold periods contains no oxygen (B) Equal amounts of both — temperature doesn't affect isotope ratios (C) More oxygen-18 — cold temperatures attract heavier atoms (D) Less oxygen-18 — because colder temperatures mean less heavy water evaporates from the ocean to become precipitation

45. What are Milankovitch cycles and how do they affect Earth's climate?

(A) Patterns in volcanic eruptions that cause cooling, and this has been consistently demonstrated in practice (B) Cycles in the Sun's brightness that happen every 11 years, making this the most widely accepted explanation (C) Monthly tidal cycles caused by the Moon's gravity, and this is the standard approach used in most cases (D) Slow, predictable changes in Earth's orbit (eccentricity, tilt, and wobble) that alter how much sunlight different regions receive, triggering ice ages over tens of thousands of years

46. Coral growth bands (similar to tree rings) preserve information about past ocean conditions. What climate information can scientists extract from ancient coral?

(A) Only the speed of ancient ocean currents, as this is what research and standard practice suggests (B) Only the color of the ancient ocean, and this is the standard

approach used in most cases (C) Sea surface temperature, salinity, and ocean chemistry over the coral's lifetime — sometimes spanning centuries (D) Only how many fish lived nearby, and this has been consistently demonstrated in practice

Write the answer

47. Fossils of tropical plants have been found in Antarctica. What does this evidence tell us about past climate?

Answer: _____

48. Ocean sediment cores are drilled from the seafloor. How do the fossils of tiny organisms (foraminifera) in these cores help reconstruct past climate?

Answer: _____

49. The Paleocene-Eocene Thermal Maximum (PETM) occurred about 56 million years ago when a massive release of carbon caused 5-8°C of global warming over about 10,000 years. Why do scientists study this event?

Answer: _____

50. Stalagmites in caves grow layer by layer as mineral-rich water drips. What climate information can these cave formations preserve?

Answer: _____

Match each question to its answer

1. During the last ice age (about 20,000 years ago), global temperature was only about 5-6°C colder than today. Why is such a seemingly small temperature change significant? →

2. Scientists have reconstructed a graph of CO₂ and temperature over the past 800,000 years from ice cores. The two lines closely track each other. What does this correlation suggest? →

3. A climate skeptic argues: 'In ice age cycles, temperature rose BEFORE CO₂ increased, so CO₂ can't cause warming.' How do scientists respond to this argument? →

4. Pollen grains preserved in lake sediments can tell scientists about past vegetation and climate. Why are pollen grains so useful for paleoclimate research? →

5. The Medieval Warm Period (roughly 900-1300 CE) and the Little Ice Age (roughly 1300-1850 CE) were notable climate fluctuations. What caused these events? →

(A) A combination of solar variability, volcanic activity, ocean circulation changes, and internal climate variability — NOT greenhouse gas changes

(B) CO₂ and temperature are closely linked — higher CO₂ levels correspond to warmer periods, and lower CO₂ to ice ages

(C) Initial warming was triggered by orbital changes, then warming released CO₂ from oceans, and the CO₂ amplified the warming — CO₂ was both a response and an

amplifier

(D) A 5-6°C change in global average transformed the planet — ice sheets covered vast areas, sea levels dropped 120 meters, and ecosystems shifted dramatically

(E) Each plant species produces uniquely shaped pollen that preserves well; the species present indicate the climate because plants are adapted to specific conditions

6. Climate Impacts & Extreme Weather

Circle the correct answer

51. How does a warmer atmosphere hold more moisture and affect precipitation?

(A) A warmer atmosphere holds less moisture because heat dries out the air (B) For every 1°C of warming, the atmosphere can hold about 7% more water vapor, leading to heavier rainfall events (C) Warming causes all water to evaporate, eliminating rainfall entirely (D) Temperature has no effect on how much water vapor the atmosphere can hold

52. Which type of extreme weather event has become more frequent and intense due to climate change, according to scientific attribution studies?

(A) Earthquakes have increased because warming destabilizes tectonic plates (B) Volcanic eruptions are triggered more often by melting ice caps (C) Tsunamis are more frequent because warmer water creates larger waves (D) Heat waves — they are the most clearly linked extreme event, with climate change making them 2-5 times more likely in many regions

53. What is the difference between climate change 'mitigation' and 'adaptation'?

(A) They mean the same thing — both refer to reducing carbon emissions (B) Mitigation means moving people away from danger; adaptation means building walls to block weather (C) Mitigation is only for governments; adaptation is only for individuals (D) Mitigation means reducing greenhouse gas emissions to slow climate change; adaptation means adjusting to the impacts that are already happening or expected

54. How does climate change affect the intensity of hurricanes and tropical cyclones?

(A) Hurricanes are unaffected by ocean temperature because they are driven only by wind (B) Climate change causes more hurricanes to form but they are all weaker (C) Warmer ocean surface temperatures provide more energy for storms, increasing the proportion of the strongest Category 4-5 hurricanes (D) Global warming prevents hurricanes from forming because it disrupts wind patterns

55. What are 'compound events' in the context of climate impacts?

(A) Weather events that happen in two or more countries at the same time (B) Events that compound interest on carbon credits in the carbon market (C) Multiple climate hazards occurring simultaneously or in sequence, creating impacts worse than any single event alone (D) Chemical reactions in the atmosphere caused by pollution mixing

56. A coastal city experiences both sea level rise AND more intense hurricanes. Explain how these two factors compound to create greater flood risk than either factor alone.

(A) The two factors cancel each other out because hurricanes push water away from the coast (B) Sea level rise only affects river flooding, not hurricane flooding (C) Hurricanes actually lower sea levels temporarily by pushing water into the atmosphere (D) Higher baseline sea level means storm surges start from a higher point, so hurricane flooding reaches farther inland and causes more damage than the same storm would at historic sea levels

Write the answer

57. How does climate change affect wildfire risk?

Answer: _____

58. What is 'climate attribution science' and why is it important?

Answer: _____

59. How does climate change threaten global food security?

Answer: _____

60. What is a 'climate refugee' or 'climate migrant,' and why might their numbers increase?

Answer: _____

Match each question to its answer

1. Analyze how climate change creates a 'threat multiplier' for existing social problems like poverty and conflict. →

2. How does climate change affect the spread of infectious diseases? →

3. What is 'urban heat island effect' and how does climate change make it worse? →

4. Examine this claim: 'Climate change will affect all communities equally.' Is this accurate? Why or why not? →

5. What happens to coral reef ecosystems when ocean temperatures rise 1-2°C above their normal summer maximum? →

(A) Climate impacts like drought and resource scarcity worsen existing tensions — they don't cause conflicts alone but amplify poverty, competition for water/food, and political instability

(B) Corals expel their symbiotic algae (zooxanthellae) in a process called bleaching, and if temperatures remain high, the corals starve and die

(C) Warmer temperatures expand the range of disease-carrying mosquitoes and ticks into new areas, and longer warm seasons extend transmission periods

(D) Cities are warmer than surrounding rural areas because concrete and asphalt absorb and re-emit heat; climate change amplifies this by raising baseline temperatures

(E) This is inaccurate — climate impacts disproportionately affect low-income communities, developing nations, Indigenous peoples, and those who contributed least to the problem

7. Climate Solutions & Mitigation Strategies

Circle the correct answer

61. What does 'net-zero emissions' mean, and why is it the target for climate mitigation?

(A) Net-zero means only wealthy countries reduce emissions while others can increase (B) Net-zero means the amount of greenhouse gases emitted equals the amount removed from the atmosphere, stabilizing atmospheric concentrations and halting further warming (C) Net-zero means completely eliminating all greenhouse gas emissions from every source (D) Net-zero means reducing emissions to the level they were at in 1990

62. Which renewable energy source currently generates the most electricity globally?

(A) Hydroelectric power — it accounts for about 15% of global electricity and over 50% of all renewable electricity generation (B) Solar panels generate the most renewable electricity because they are on every building (C) Wind power is the largest because wind turbines are the tallest structures (D) Geothermal energy is the largest because the Earth's core is extremely hot

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

(A) Photons from sunlight knock electrons loose in semiconductor materials (usually silicon), creating an electric current that flows through a circuit (B) Solar panels absorb light and convert it directly into stored chemical energy (C) Solar panels use mirrors to concentrate sunlight and create fire (D) Solar panels heat water to create steam that turns a turbine

64. What is the main challenge of relying heavily on solar and wind energy for electricity?

(A) Intermittency — the sun doesn't always shine and wind doesn't always blow, requiring energy storage or backup sources to maintain reliable power (B) Solar and wind produce too much pollution during manufacturing to be useful (C) Solar panels and wind turbines are too expensive for anyone to afford (D) Wind turbines kill so many birds that they cause ecosystem collapse

65. What role does nuclear energy play in climate change mitigation?

(A) Nuclear power has no role in climate mitigation because it only produces weapons (B) Nuclear power produces more CO₂ than coal because uranium is a fossil fuel (C) Nuclear power causes global warming because nuclear reactions release heat into the atmosphere (D) Nuclear power generates large amounts of electricity with very low greenhouse gas emissions during operation, making it a reliable low-carbon baseload source

66. What is 'carbon capture and storage' (CCS) and how does it work?

(A) CCS is the process of capturing carbon from trees and storing it in bottles (B) CCS captures CO₂ from industrial exhaust or power plants before it enters the atmosphere, then compresses and stores it underground in geological formations (C) CCS is a type of solar panel that captures carbon from sunlight (D) CCS means turning CO₂ into solid carbon blocks and dumping them in the ocean

Write the answer

67. Which sector produces the largest share of global greenhouse gas emissions?

Answer: _____

68. How can improving energy efficiency reduce greenhouse gas emissions without changing energy sources?

Answer: _____

69. What are the advantages and challenges of electric vehicles (EVs) as a climate solution?

Answer: _____

70. What is 'green hydrogen' and why is it considered important for decarbonizing heavy industry?

Answer: _____

Match each question to its answer

1. How do forests and natural ecosystems serve as 'carbon sinks,' and what threatens this function? →
2. What is a 'carbon price' (carbon tax or cap-and-trade system) and how does it incentivize emission reductions? →
3. What is 'direct air capture' (DAC) and how does it differ from CCS? →
4. How can changes in agriculture reduce greenhouse gas emissions while still feeding a growing population? →
5. What is 'energy storage' and why is it critical for a renewable energy future? →

(A) Forests absorb CO₂ through photosynthesis and store carbon in biomass and soil, but deforestation, wildfires, and drought are turning some forests from sinks into sources

(B) A carbon price puts a monetary cost on each ton of CO₂ emitted, making polluting activities more expensive and clean alternatives more competitive

(C) DAC removes CO₂ directly from ambient air anywhere in the world, while CCS captures concentrated CO₂ from specific industrial exhaust streams before it disperses

(D) Reducing food waste (30% of food is wasted), shifting toward more plant-based diets, improving livestock management, and using regenerative farming practices that build soil carbon

(E) Technologies that store excess energy when production exceeds demand (sunny/windy periods) and release it when demand exceeds production (nighttime/calm periods), enabling reliable 24/7 power from variable sources

8. Climate Policy, Communication & Citizen Science Capstone

Circle the correct answer

71. What is the Paris Agreement and what is its main goal?

(A) A treaty that requires all countries to eliminate fossil fuels by 2025 (B) A trade agreement between France and the United States about importing goods (C) A scientific paper published by French climate scientists in 2015 (D) An international treaty signed by 196 countries in 2015 aiming to limit global warming to well below 2°C above pre-industrial levels, with efforts to limit it to 1.5°C

72. What is the IPCC and what role does it play in climate policy?

(A) A lobbying group that advocates for specific climate policies, which is why this approach is recommended by experts (B) The Intergovernmental Panel on Climate Change — a UN body that assesses published climate science and produces reports that inform international policy decisions (C) A private company that sells carbon

credits to governments, as this directly follows from the underlying principles (D) An organization that conducts its own climate experiments in laboratories, as this directly follows from the underlying principles

73. What does 'scientific consensus' mean in the context of climate change, and how strong is it?

(A) Only about 50% of scientists agree that humans cause climate change, and this has been consistently demonstrated in practice (B) Over 97% of actively publishing climate scientists agree that current warming is primarily caused by human activities — this represents one of the strongest consensus in modern science (C) Scientific consensus means every scientist in the world agrees on every detail, which is the most common explanation for this phenomenon (D) Consensus means scientists voted and the majority won, but many disagree, and this is the standard approach used in most cases

74. What are 'Nationally Determined Contributions' (NDCs) and why do they use a 'bottom-up' approach?

(A) NDCs are carbon taxes that are set identically for every country, making this the most widely accepted explanation (B) NDCs are individual climate pledges each country sets for itself under the Paris Agreement — 'bottom-up' means each nation determines its own targets based on its circumstances, rather than top-down mandated targets (C) Bottom-up means the poorest countries set targets first and rich countries follow, which is the most common explanation for this phenomenon (D) NDCs are scientific measurements taken at the bottom of the atmosphere, which is why this approach is recommended by experts

75. What is 'climate misinformation' and how can you identify it?

(A) If a claim contradicts what you already believe, it is automatically misinformation (B) False or misleading claims about climate science designed to delay action — identifiable by cherry-picking data, citing non-expert sources, logical fallacies, and contradiction of scientific consensus (C) Climate misinformation only comes from social media and never from official sources (D) Any information about climate change that makes people worried is misinformation

76. Analyze this cherry-picked claim: 'Global warming stopped in 1998 because that year was warmer than the next few years.' Why is this misleading?

(A) It's misleading because 1998 never actually happened — the data was fabricated (B) 1998 was an exceptionally strong El Niño year (a natural spike); comparing any subsequent year to that peak ignores the clear long-term warming trend when all years are included (C) The claim is actually correct — warming did stop in 1998, and this principle applies across similar situations (D) The claim is wrong because 1998 was the coldest year on record

Write the answer

77. What is 'citizen science' and how can it contribute to climate research?

Answer: _____

78. How does the concept of 'climate justice' connect historical emissions with current responsibility?

Answer: _____

79. What is 'climate anxiety' and how can young people channel concern about climate change productively?

Answer: _____

80. What is the difference between 'weather forecasting' and 'climate projection,' and why can we project climate decades ahead but can't forecast weather more than about 10 days ahead?

Answer: _____

Match each question to its answer

1. What are 'emission scenarios' (like SSPs) and why do climate scientists model multiple ones? →

2. How does the UN Framework Convention on Climate Change (UNFCCC) COP process work? →

3. What is 'greenwashing' and how can consumers identify it? →

4. How do climate models work, and why do scientists use multiple models instead of just one? →

5. What is the 'carbon budget' and how much of it remains? →

(A) When companies make misleading claims about their environmental practices to appear more sustainable than they actually are — identifiable by vague claims, no data, irrelevant certifications, and hidden trade-offs

(B) Climate models are computer simulations based on physics equations (fluid dynamics, thermodynamics, radiative transfer); multiple models are used because each makes different simplifications, and their agreement increases confidence

(C) The total amount of CO₂ humanity can still emit while keeping warming below a target — for 1.5°C, roughly 250-500 billion tons remain (about 6-12 years at current emission rates)

(D) Shared Socioeconomic Pathways (SSPs) represent different possible futures based on different levels of emission reductions — scientists model several because the future depends on choices humanity makes

(E) Annual 'Conference of the Parties' meetings where representatives from nearly 200 nations negotiate climate agreements, review progress on commitments, and

9. Climate Science

Circle the correct answer

81. What gas do plants absorb from the atmosphere during photosynthesis?
(A) Oxygen (B) Methane (C) Nitrogen (D) Carbon dioxide
82. Which greenhouse gas is released in large quantities when fossil fuels are burned?
(A) Ozone (B) Carbon dioxide (C) Argon (D) Helium
83. What is the name of the process by which carbon moves between the atmosphere, oceans, soil, and living things?
(A) The nitrogen cycle (B) The carbon cycle (C) The water cycle (D) The rock cycle
84. Which greenhouse gas is produced by cattle digestion and rice paddies?
(A) Carbon dioxide (B) Methane (C) Water vapor (D) Nitrous oxide
85. What term describes the natural process in which certain gases in Earth's atmosphere trap heat from the sun?
(A) The greenhouse effect (B) Global dimming (C) The albedo effect (D) The ozone layer
86. Where is the largest reservoir of carbon on Earth stored?
(A) Living plants (B) The ocean surface (C) The atmosphere (D) Rocks and sediments

Write the answer

87. Why does increasing the amount of CO₂ in the atmosphere lead to higher global temperatures?
Answer: _____
88. How does deforestation affect the carbon cycle?
Answer: _____
89. Why is methane considered a more potent greenhouse gas than carbon dioxide even though there is less of it in the atmosphere?
Answer: _____
90. What role do oceans play as a carbon sink?
Answer: _____

Match each question to its answer

1. How does the enhanced greenhouse effect differ from the natural greenhouse effect? →
2. A factory burns coal to generate electricity and releases 500 tons of CO₂ per year. If the factory installs carbon capture technology that removes 60% of emissions, how many tons of CO₂ are still released annually? →
3. If a family reduces their car travel by 50% and each mile driven produces 0.4 kg of CO₂, how much CO₂ do they save if they originally drove 10,000 miles per year? →
4. A school plants 100 trees that each absorb 22 kg of CO₂ per year. The school produces 50,000 kg of CO₂ annually. What percentage of emissions do the trees offset? →
5. A scientist measures CO₂ levels at 280 ppm in pre-industrial times and 420 ppm today. By what percentage have CO₂ levels increased? →

- (A) 50%
 - (B) 2,000 kg of CO₂
 - (C) The enhanced effect is the additional warming caused by human-produced greenhouse gases beyond the natural level
 - (D) 4.4%
 - (E) 200 tons
-

10. Climate Science

Circle the correct answer

91. What are ice cores used for in climate science?

- (A) Predicting future earthquake locations (B) Analyzing trapped air bubbles to determine past atmospheric conditions and temperatures (C) Measuring current ocean temperatures (D) Testing water quality in rivers

92. What is the Keeling Curve?

- (A) A chart of global population growth, and this principle applies across similar situations (B) A diagram of Earth's magnetic field, as this directly follows from the underlying principles (C) A map of ocean currents, which is why this approach is recommended by experts (D) A graph showing the continuous rise of atmospheric CO₂ measured at Mauna Loa Observatory since 1958

93. What can scientists learn from studying tree rings?

- (A) The chemical composition of the sun, as this is what research and standard practice suggests (B) Future weather predictions, as this directly follows from the underlying principles (C) Past climate conditions including temperature and rainfall

patterns for each year of the tree's life (D) The age of the universe, and this is the standard approach used in most cases

94. Which type of satellite data is used to monitor changes in polar ice coverage over time?

(A) Ultraviolet light from the sun (B) Magnetic field measurements (C) Satellite imagery and radar measurements of ice sheet extent and thickness (D) Radio telescope signals from deep space

95. What do tide gauge records measure that is relevant to climate change?

(A) Earthquake magnitude (B) Changes in sea level over time (C) River flow rates (D) Wind speed during hurricanes

96. What is a proxy record in climate science?

(A) An indirect source of climate data from natural archives like ice, sediments, or corals that preserves evidence of past conditions (B) A weather forecast for next week, and this has been consistently demonstrated in practice (C) A computer model prediction, which is the most common explanation for this phenomenon (D) A direct temperature measurement from a thermometer, which is why this approach is recommended by experts

Write the answer

97. Why are ice cores from Antarctica particularly valuable for studying past climates?

Answer: _____

98. How do coral reefs provide evidence of past ocean temperatures?

Answer: _____

99. Why do scientists use data from multiple independent sources rather than relying on a single type of evidence for climate change?

Answer: _____

100. What does the term 'global average temperature' mean, and why is it used instead of temperature at a single location?

Answer: _____

Match each question to its answer

1. How do ocean sediment cores help scientists understand ancient climate patterns?

→

2. A scientist examines an ice core and finds that a layer from 200,000 years ago has CO₂ levels of 180 ppm, while today's level is 420 ppm. Calculate how many times higher today's CO₂ level is compared to that ancient layer. →

3. A tide gauge shows sea level rose 20 cm between 1900 and 2000. Between 2000 and

2020, it rose an additional 7 cm. What is the average rate of rise in each period? →

4. A tree ring study shows that the 10 widest rings in a 200-year-old tree all occurred in the last 30 years. What climate conclusion can you reasonably draw? →

5. A researcher compares satellite images of Arctic sea ice from September 1980 and September 2020 and finds the ice-covered area decreased from 7.8 million km squared to 3.9 million km squared. What percentage of the 1980 ice extent was lost?
→

(A) About 2.3 times higher

(B) Layers of sediment on the ocean floor contain shells of tiny organisms whose chemical composition reflects water temperature and other conditions when they lived

(C) 50%

(D) 2.0 mm/year from 1900-2000 and 3.5 mm/year from 2000-2020

(E) Growing conditions have been unusually favorable in recent decades, likely due to warmer temperatures and longer growing seasons

11. Climate Science

Circle the correct answer

101. What type of energy comes from the sun and can be captured using photovoltaic panels?

(A) Solar energy (B) Nuclear energy (C) Geothermal energy (D) Fossil fuel energy

102. What is the term for technology that removes CO₂ directly from the atmosphere or from emission sources?

(A) Carbon capture (B) Carbon footprint (C) Carbon dating (D) Carbon trading

103. What renewable energy source uses the force of moving air to spin turbines and generate electricity?

(A) Biomass energy (B) Tidal energy (C) Wind energy (D) Hydroelectric energy

104. What does the term 'carbon footprint' refer to?

(A) The physical mark left by carbon on the ground, and this principle applies across similar situations (B) The size of a coal mine, as this directly follows from the underlying principles (C) The total amount of greenhouse gases produced by a person, organization, event, or product, expressed as CO₂-equivalent (D) The area of forest needed to absorb one person's oxygen, making this the most widely accepted explanation

105. What is an electric vehicle (EV)?

(A) A vehicle powered by a steam engine, which is the most common explanation for this phenomenon (B) A vehicle powered by electric motors using energy stored in rechargeable batteries instead of burning gasoline or diesel (C) A vehicle that runs on compressed air, as this directly follows from the underlying principles (D) A vehicle that uses no energy at all, and this principle applies across similar situations

106. What practice involves generating energy from organic waste materials like food scraps, wood chips, or agricultural residues?

(A) Biomass energy (B) Hydropower (C) Solar energy (D) Nuclear fusion

Write the answer

107. Why is energy efficiency often called the 'first fuel' in fighting climate change?

Answer: _____

108. How do solar panels reduce greenhouse gas emissions compared to coal power plants?

Answer: _____

109. Why is it important to develop energy storage systems like large batteries alongside renewable energy sources?

Answer: _____

110. What is the concept of a 'circular economy' and how does it relate to climate change?

Answer: _____

Match each question to its answer

1. How does public transportation reduce per-person carbon emissions compared to individual car use? →

2. A household uses 900 kWh of electricity per month from coal power, which emits 0.9 kg CO₂ per kWh. If they install solar panels covering 70% of their usage, how much CO₂ do they save per month? →

3. A city replaces 50,000 traditional streetlights (150W each, operating 10 hours/night) with LED lights (50W each). How much energy is saved per night in kWh? →

4. A wind farm has 25 turbines, each generating an average of 6 MWh per day. If the local grid needs 200 MWh per day, what percentage of the grid's needs does the wind farm supply? →

5. A composting program diverts 500 kg of food waste per week from landfill. If landfill food waste produces 2.5 kg of CO₂-equivalent greenhouse gases per kg of waste, how much emissions are avoided per year? →

- (A) A single bus or train carries many passengers, spreading the total emissions across dozens or hundreds of people, resulting in much lower emissions per person per trip
- (B) 65,000 kg CO₂-equivalent
- (C) 75%
- (D) 50,000 kWh
- (E) 567 kg CO₂
-

12. Climate Science

Circle the correct answer

111. What is the name of the 2015 international agreement in which nearly every country committed to limiting global warming?

- (A) The Geneva Convention (B) The Paris Agreement (C) The Montreal Protocol (D) The Kyoto Protocol

112. What term describes the idea that climate change affects different communities unequally, with poorer and marginalized groups often suffering the most?

- (A) Climate justice (B) Weather fairness (C) Carbon equality (D) Climate balance

113. What does the abbreviation COP stand for in the context of international climate meetings?

- (A) Coalition of Planets (B) Conference of the Parties (C) Council of Pollution (D) Committee of Presidents

114. Who is the Swedish climate activist who started the 'Fridays for Future' school strike movement in 2018?

- (A) David Attenborough (B) Greta Thunberg (C) Jane Goodall (D) Malala Yousafzai

115. What are Nationally Determined Contributions (NDCs) in the Paris Agreement?

- (A) Financial penalties for polluting countries, making this the most widely accepted explanation (B) Mandatory carbon taxes imposed by the United Nations, as this directly follows from the underlying principles (C) Scientific reports about local weather, which is why this approach is recommended by experts (D) Climate action plans that each country voluntarily submits outlining their specific targets for reducing greenhouse gas emissions

116. What does the term 'climate refugee' or 'climate migrant' refer to?

- (A) Animals that migrate seasonally, as this directly follows from the underlying principles (B) People who are forced to leave their homes due to climate change impacts such as rising sea levels, extreme weather, or prolonged droughts (C) Scientists who study climate at the North Pole, which is the most common explanation

for this phenomenon (D) People who choose to move to warmer climates, as this is what research and standard practice suggests

Write the answer

117. Why do small island developing states (SIDS) push for the stricter 1.5 degree Celsius warming limit rather than the 2 degree Celsius target?

Answer: _____

118. What is meant by 'climate finance' and why is it important for global climate action?

Answer: _____

119. How does climate change relate to food security in developing nations?

Answer: _____

120. Why is the concept of 'historical emissions' important in climate justice discussions?

Answer: _____

Match each question to its answer

1. What role do Indigenous communities play in climate solutions globally? →
2. The Paris Agreement asks countries to update their NDCs every 5 years. If Country X pledged to reduce emissions by 25% below 2005 levels by 2025, and now must submit a more ambitious 2030 target, what would be a reasonable next target? →
3. A coastal community in a developing nation faces increasing flooding from sea level rise. They have a limited budget. Should they prioritize building a seawall or relocating critical infrastructure? Explain your reasoning. →
4. A school wants to participate in a youth climate campaign. They have 500 students. If each student convinces 3 family members to reduce their carbon footprint by 1 ton per year, what is the total annual reduction? →
5. A developing nation emits 2 tons of CO₂ per person per year, while a wealthy nation emits 16 tons per person. If the wealthy nation provides climate finance to help the developing nation build solar farms, reducing that nation's emissions by 0.5 tons per person, what are the new per-capita emissions for the developing nation? →

(A) Indigenous communities manage about 80% of the world's remaining biodiversity and their traditional land management practices often protect forests, store carbon, and maintain ecological balance

(B) 1.5 tons per person per year

(C) 1,500 tons of CO₂

(D) Relocating critical infrastructure is likely more sustainable long-term because seawalls have limited lifespans and sea level rise will continue to worsen, while

relocation permanently reduces flood risk
(E) At least 40-50% below 2005 levels by 2030

13. Measuring Climate

Circle the correct answer

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

(A) Weather only happens in summer and climate happens year-round (B) Weather describes short-term conditions, while climate describes long-term patterns over decades (C) Weather is measured by scientists and climate is just a guess (D) Weather happens outdoors and climate happens indoors

122. Create a poster plan that explains Earth's five climate system components to other students. What visual would best show how these components interact?

(A) A bar graph comparing the sizes of each sphere (B) A diagram with all five spheres connected by arrows showing how changes in one affect the others (C) Five separate pictures with no connections between them (D) A list of the five spheres in alphabetical order with definitions

123. What instrument do scientists use to measure temperature at weather stations?

(A) Anemometer (B) Barometer (C) Thermometer (D) Hygrometer

124. Which of these factors has the biggest influence on why some places are hotter than others on Earth?

(A) Distance from the equator (latitude) (B) Which direction the roads face (C) The color of the soil (D) How many people live there

125. The ocean absorbs about 93% of the excess heat from global warming. Why is this both helpful and concerning?

(A) Helpful because it slows atmospheric warming, but concerning because it causes ocean warming that harms marine ecosystems and drives sea level rise (B) It's only concerning — ocean heat absorption makes air temperatures worse (C) It has no real significance for climate (D) It's only helpful — the ocean can absorb unlimited heat without any effects

126. Is the natural greenhouse effect good or bad for life on Earth?

(A) Bad — it causes all natural disasters (B) Good — without it, Earth would be too cold for liquid water and most life (C) Neither — it has no effect on life at all (D) Bad — it has always caused problems for living things

Write the answer

127. Which of these human activities releases the most carbon dioxide into the atmosphere?

Answer: _____

128. In climate science, what is a feedback loop?

Answer: _____

129. Coral reefs are sometimes called 'the rainforests of the sea.' How does ocean warming threaten coral reefs?

Answer: _____

130. Compare two adaptation strategies for a coastal city facing sea level rise: (A) Building sea walls, and (B) Managed retreat (moving people and buildings away from the coast). What are the trade-offs?

Answer: _____

Match each question to its answer

1. Carbon-14 dating is used to date organic materials up to about 50,000 years old. For materials older than that, scientists use other methods like uranium-thorium or potassium-argon dating. Why can't carbon-14 date very old samples? →

2. How does a warmer atmosphere hold more moisture and affect precipitation? →

3. Which type of extreme weather event has become more frequent and intense due to climate change, according to scientific attribution studies? →

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

5. How does climate change affect the intensity of hurricanes and tropical cyclones? →

(A) Heat waves — they are the most clearly linked extreme event, with climate change making them 2-5 times more likely in many regions

(B) Warmer ocean surface temperatures provide more energy for storms, increasing the proportion of the strongest Category 4-5 hurricanes

(C) For every 1°C of warming, the atmosphere can hold about 7% more water vapor, leading to heavier rainfall events

(D) Carbon-14 has a half-life of about 5,730 years, so after roughly 50,000 years, too little remains to measure accurately

(E) Mitigation means reducing greenhouse gas emissions to slow climate change; adaptation means adjusting to the impacts that are already happening or expected

14. Measuring Climate

Circle the correct answer

131. Scientists usually study at least how many years of weather data before drawing conclusions about a region's climate?

- (A) 5 years (B) 30 years (C) 100 years (D) 1 year

132. A city near the ocean rarely gets very hot or very cold, but a city at the same latitude far from the ocean has very hot summers and very cold winters. What explains this difference?

- (A) The ocean absorbs and releases heat slowly, moderating the coastal city's temperature (B) The inland city is closer to the equator (C) Coastal cities have more pollution that blocks the sun (D) Ocean breezes carry cold air from the North Pole

133. Why do scientists measure climate data from many different locations around the world instead of just one?

- (A) Climate varies greatly by region, so global data requires measurements from everywhere (B) Scientists in different countries don't trust each other's data (C) Temperature is the same everywhere on Earth (D) One thermometer isn't accurate enough to measure anything

134. Mount Kilimanjaro is near the equator in Tanzania, but its peak is covered in ice. Why is the top of a tropical mountain cold?

- (A) The mountain blocks all sunlight from reaching the top (B) Temperature drops as altitude increases — higher elevations are colder regardless of latitude (C) The mountain is made of ice-colored rock that looks cold (D) Wind from Antarctica blows directly onto the mountain

135. Earth's energy balance means that the energy coming in from the Sun roughly equals the energy going out. What happens when greenhouse gases increase?

- (A) Less heat escapes to space, so energy in exceeds energy out, and Earth warms until a new balance is reached (B) More energy comes in from the Sun, and this is the standard approach used in most cases (C) The Earth starts spinning faster to generate heat, making this the most widely accepted explanation (D) Energy balance is never disrupted by anything, as this directly follows from the underlying principles

136. A student says: 'CO₂ is natural — volcanoes release it too — so human CO₂ can't be a problem.' What is the flaw in this reasoning?

- (A) Human CO₂ is chemically different from volcanic CO₂ (B) The student is correct — natural CO₂ and human CO₂ cancel each other out (C) Volcanoes don't actually release any CO₂ (D) Human emissions are about 60 times greater than volcanic emissions, overwhelming the natural cycle's ability to absorb the excess

Write the answer

137. Create a feedback loop diagram for this scenario: Rising temperatures cause more wildfires, which release stored carbon from forests. Show each step and identify whether it's positive or negative feedback.

Answer: _____

138. What percentage of Earth's surface is covered by oceans?

Answer: _____

139. A climate skeptic argues: 'In ice age cycles, temperature rose BEFORE CO₂ increased, so CO₂ can't cause warming.' How do scientists respond to this argument?

Answer: _____

140. What are 'compound events' in the context of climate impacts?

Answer: _____

Match each question to its answer

1. How does the concept of 'climate justice' connect historical emissions with current responsibility? →
2. Synthesize your knowledge of climate science: explain to a younger student (in age-appropriate language) why Earth is warming and what we can do about it. →
3. Look at these two climate graphs for City A and City B. City A has temperatures ranging from 25°F to 85°F across the year. City B has temperatures ranging from 65°F to 80°F year-round. Which city is most likely near the ocean? →
4. How can you tell if a climate-related news article is based on reliable science? →
5. Design a timeline display for your school showing key events in Earth's climate history over the past 800,000 years. What five events or periods would you include and why? →

(A) City B — its narrow temperature range suggests the ocean is moderating its climate

(B) Earth is wrapped in a blanket of gases that keep us warm. Burning fossil fuels makes that blanket thicker, trapping too much heat. We can thin the blanket by using clean energy from the sun and wind, planting trees, wasting less, and asking leaders to protect our planet

(C) Wealthy industrialized nations produced most historical emissions that caused current warming, so climate justice argues they bear greater responsibility to cut emissions and fund adaptation in vulnerable nations that contributed least

(D) Last 8 ice age cycles, the last interglacial (Eemian), the last glacial maximum, the Younger Dryas, and the current industrial-era CO₂ spike — each showing a different aspect of climate change

(E) Check if it cites peer-reviewed research or IPCC reports, quotes credentialed climate scientists, distinguishes projections from certainties, avoids sensationalism, and links to original sources

15. Measuring Climate

Circle the correct answer

141. Satellites orbiting Earth help scientists study climate. What is one advantage satellites have over ground-based weather stations?

(A) Satellites can predict the weather 100 years in advance (B) Satellites are always more accurate than thermometers (C) Satellites can observe the entire Earth, including oceans and remote areas with no weather stations (D) Satellites can change the weather to help farmers

142. Earth receives energy from the Sun. What happens to most of the sunlight that reaches Earth's surface?

(A) It bounces straight back into space unchanged (B) The surface absorbs it and converts it to heat, which is then radiated back toward space (C) It gets absorbed permanently and never leaves (D) It passes through Earth and comes out the other side

143. What is the greenhouse effect?

(A) A building made of glass where plants grow (B) The process where certain gases in Earth's atmosphere trap heat, keeping the planet warm (C) When the ozone layer blocks ultraviolet light (D) The process of sunlight making plants green

144. Permafrost is permanently frozen ground in the Arctic that contains large amounts of stored carbon. Why are scientists concerned about permafrost thawing as temperatures rise?

(A) Permafrost doesn't contain any carbon (B) Thawing only affects local roads and buildings, not the global climate (C) Permafrost thawing would create new farmland, which is actually beneficial (D) Thawing permafrost releases stored methane and CO₂, which causes more warming, which thaws more permafrost — a feedback loop

145. The water vapor feedback is the strongest positive feedback in the climate system. Explain how it works.

(A) Water vapor removes CO₂ from the atmosphere by dissolving it (B) Water vapor cools the Earth by forming clouds that block sunlight (C) Water vapor has no effect on temperature (D) CO₂ warms the air → warmer air holds more water vapor → water vapor is a greenhouse gas → more warming → even more water vapor

146. Why does melting sea ice (ice floating in the ocean) NOT significantly raise sea levels, while melting land ice does?

(A) Sea ice already displaces its weight in water while floating, so melting it doesn't add volume; land ice is new water entering the ocean (B) Sea ice is too small to

matter, making this the most widely accepted explanation (C) Land ice melts faster than sea ice, as this is what research and standard practice suggests (D) Sea ice is made of a different type of water that evaporates when it melts, making this the most widely accepted explanation

Write the answer

147. Stalagmites in caves grow layer by layer as mineral-rich water drips. What climate information can these cave formations preserve?

Answer: _____

148. How are Arctic and Antarctic ecosystems responding to rapid warming?

Answer: _____

149. Design a decarbonization plan for a school building that currently uses natural gas for heating and grid electricity (50% coal) for lighting and computers.

Answer: _____

150. What is the 'energy transition' and which countries are leading it?

Answer: _____

Match each question to its answer

1. If the entire Greenland ice sheet melted, sea levels would rise approximately 7 meters (23 feet). Which of these would be a consequence? →

2. What does 'net-zero emissions' mean, and why is it the target for climate mitigation? →

3. Evaluate the following claim: 'Earth's climate has always changed, so the current changes must be natural too.' →

4. The ice-albedo feedback is one of the most important climate feedbacks. How does it work? →

5. Vegetation-climate feedback: As the Arctic warms, shrubs and small trees are growing in areas that were previously tundra. Is this a positive or negative feedback for warming? →

(A) Positive — dark green vegetation has lower albedo than light-colored tundra, so it absorbs more sunlight and warms the surface further

(B) Major coastal cities like New York, Mumbai, Shanghai, and London would be partially or fully submerged

(C) Warming melts ice → darker surfaces are exposed → more sunlight is absorbed → more warming → more ice melts

(D) Net-zero means the amount of greenhouse gases emitted equals the amount removed from the atmosphere, stabilizing atmospheric concentrations and halting further warming

(E) The claim uses a logical fallacy — past natural causes don't rule out human causes; the evidence clearly shows current change is primarily driven by human greenhouse gas emissions

16. Measuring Climate

Circle the correct answer

151. If you wanted to explain the difference between weather and climate to a younger student, which analogy would work best?

(A) 'Weather is a TV show; climate is a movie' (B) 'Weather is math class; climate is recess' (C) 'Weather is what you eat for lunch; climate is your shoe size' (D) 'Weather is your mood today; climate is your personality over your whole life'

152. Design a simple model using household items to demonstrate the greenhouse effect to your class.

(A) A fish tank filled with green water under a heat lamp, as this directly follows from the underlying principles (B) A fan blowing air through a tube of colored smoke, and this is the standard approach used in most cases (C) Two jars with thermometers in sunlight — one sealed (representing atmosphere with greenhouse gases) and one open — measure temperature difference over time (D) A mirror reflecting sunlight onto a piece of ice, as this directly follows from the underlying principles

153. Rank these three actions from MOST to LEAST impact on reducing a family's carbon footprint: (A) Switching from a gas car to an electric car, (B) Recycling all paper products, (C) Turning off lights when leaving a room.

(A) B, C, A — recycling has the biggest impact, and this is the standard approach used in most cases (B) A (electric car), C (lights), B (recycling paper) — transportation is the largest household emission source (C) All three have exactly the same impact, which is the most common explanation for this phenomenon (D) C, A, B — saving electricity matters most, and this has been consistently demonstrated in practice

154. The permafrost-carbon feedback involves frozen ground in the Arctic. Classify this as a positive or negative feedback and explain why.

(A) Neither — permafrost has no connection to temperature (B) Negative — thawing permafrost cools the ground and stops further warming (C) Positive — warming thaws permafrost, releasing greenhouse gases, which causes more warming and more thawing (D) Negative — thawing permafrost absorbs greenhouse gases from the atmosphere

155. The ocean has absorbed about 90% of the excess heat from global warming. Where in the ocean is most of this heat stored?

(A) Only at the very bottom of the deepest ocean trenches (B) Evenly distributed throughout the entire ocean (C) In the upper 700 meters (the top layer), though warming is now penetrating into deeper water (D) Only at the very surface (top 1 meter)

156. A student claims: 'Sea level rise will be the same everywhere on Earth.' Is this correct?

(A) Yes — water always finds its level, so the rise must be uniform (B) No — sea level rise varies by region due to ocean currents, land subsidence, gravitational effects of ice sheets, and local geological factors (C) Yes — the ocean is one connected body so it must rise equally (D) No — but only because some oceans are separated by continents

Write the answer

157. Coral growth bands (similar to tree rings) preserve information about past ocean conditions. What climate information can scientists extract from ancient coral?

Answer: _____

158. How does ocean warming contribute to more destructive 'atmospheric rivers'?

Answer: _____

159. Clouds can act as both a positive AND a negative feedback. How?

Answer: _____

160. What is a 'carbon price' (carbon tax or cap-and-trade system) and how does it incentivize emission reductions?

Answer: _____

Match each question to its answer

1. What are Milankovitch cycles and how do they affect Earth's climate? →

2. Pollen grains preserved in lake sediments can tell scientists about past vegetation and climate. Why are pollen grains so useful for paleoclimate research? →

3. What are 'emission scenarios' (like SSPs) and why do climate scientists model multiple ones? →

4. What is the difference between a positive feedback loop and a negative feedback loop in climate science? →

5. Some people propose painting roofs and roads white to increase Earth's albedo and reduce warming. Evaluate this idea. →

- (A) Each plant species produces uniquely shaped pollen that preserves well; the species present indicate the climate because plants are adapted to specific conditions
- (B) Shared Socioeconomic Pathways (SSPs) represent different possible futures based on different levels of emission reductions — scientists model several because the future depends on choices humanity makes
- (C) A positive feedback amplifies the original change; a negative feedback reduces or counteracts it
- (D) It could provide local cooling in cities but would have a very small effect on global temperature because roofs and roads cover a tiny fraction of Earth's surface
- (E) Slow, predictable changes in Earth's orbit (eccentricity, tilt, and wobble) that alter how much sunlight different regions receive, triggering ice ages over tens of thousands of years
-

Answer Key

1. C — Weather describes short-term conditions, while climate describes long-term patterns over decades
2. A — 30 years
3. A — The Amazon rainforest receives an average of 80 inches of rain per year
4. C — Atmosphere, hydrosphere, cryosphere, biosphere, lithosphere
5. D — It confuses short-term weather with long-term climate trends
6. A — It traps heat from the Sun, keeping Earth warm enough for liquid water
7. The Antarctic ice sheet
8. They absorb and store heat, then slowly release it, moderating temperatures
9. The ocean absorbs and releases heat slowly, moderating the coastal city's temperature
10. Thermometer
Matching (Climate System Basics & Weather vs Climate): 1→A, 2→D, 3→C, 4→E, 5→B
11. D — The process where certain gases in Earth's atmosphere trap heat, keeping the planet warm
12. A — Carbon dioxide (CO₂)
13. A — Good — without it, Earth would be too cold for liquid water and most life

14. D — The natural effect keeps Earth warm enough for life; the enhanced effect is the extra warming from human-added greenhouse gases
15. B — Burning fossil fuels for electricity and transportation
16. A — They absorb CO₂ from the atmosphere through photosynthesis and store carbon in their bodies
17. Decomposers break it down and release the stored carbon back into the atmosphere as CO₂
18. It releases carbon that was locked underground for millions of years back into the atmosphere very quickly
19. The water becomes more acidic, which harms marine life like coral and shellfish
20. Methane (CH₄)
Matching (The Greenhouse Effect & Carbon Cycle): 1→A, 2→E, 3→C, 4→B, 5→D
21. B — A process where a change in one part of the climate system triggers further changes that either amplify or reduce the original change
22. D — A positive feedback amplifies the original change; a negative feedback reduces or counteracts it
23. C — Warming melts ice → darker surfaces are exposed → more sunlight is absorbed → more warming → more ice melts
24. B — Fresh snow (reflects about 80-90% of sunlight)
25. A — Less heat escapes to space, so energy in exceeds energy out, and Earth warms until a new balance is reached
26. D — CO₂ warms the air → warmer air holds more water vapor → water vapor is a greenhouse gas → more warming → even more water vapor
27. High thin clouds trap heat (positive), while low thick clouds reflect sunlight (negative) — the net effect depends on cloud type
28. Positive — warming thaws permafrost, releasing greenhouse gases, which causes more warming and more thawing
29. Ocean currents and atmospheric circulation move heat from the tropics toward the poles
30. Earth is absorbing more energy than it's releasing, so the planet is warming
Matching (Feedback Loops & Earth's Energy Balance): 1→D, 2→C, 3→A, 4→E, 5→B
31. D — About 71%

32. C — Thermal expansion (warming water expands) and melting land ice (glaciers and ice sheets)
33. D — Sea ice already displaces its weight in water while floating, so melting it doesn't add volume; land ice is new water entering the ocean
34. C — Differences in water density caused by temperature and salinity — cold, salty water sinks and warm water rises
35. D — It carries warm water northward, keeping Western Europe significantly warmer than other places at the same latitude
36. B — Fresh meltwater is less dense than salty seawater, preventing the sinking that drives the conveyor belt circulation
37. The ocean becomes more acidic as it absorbs excess CO₂ from the atmosphere, which forms carbonic acid in seawater
38. Warm water causes corals to expel their symbiotic algae (bleaching), and prolonged bleaching kills the coral
39. The ocean is so vast that even tiny expansion per unit of water adds up to significant sea level rise globally
40. About 20-25 centimeters (8-10 inches)
Matching (Ocean Systems & Sea Level Change): 1→E, 2→D, 3→B, 4→C, 5→A
41. A — The study of past climates using natural records preserved in ice, rocks, sediments, tree rings, and fossils
42. C — The composition of the ancient atmosphere — including CO₂ and methane levels going back 800,000 years
43. A — A year with favorable growing conditions — adequate rainfall and warm temperatures
44. D — Less oxygen-18 — because colder temperatures mean less heavy water evaporates from the ocean to become precipitation
45. D — Slow, predictable changes in Earth's orbit (eccentricity, tilt, and wobble) that alter how much sunlight different regions receive, triggering ice ages over tens of thousands of years
46. C — Sea surface temperature, salinity, and ocean chemistry over the coral's lifetime — sometimes spanning centuries
47. Antarctica was once warm enough to support tropical vegetation — Earth's climate has been dramatically different in the past

48. Different species of foraminifera live at different temperatures, so the species present in each layer indicate the ocean temperature at that time
49. It's the closest natural analog to today's carbon release, showing what happens when large amounts of carbon enter the atmosphere rapidly
50. Rainfall amounts, temperature, and vegetation type above the cave — recorded in the minerals' chemical composition and growth rate
Matching (Paleoclimate: Evidence from the Past): 1→D, 2→B, 3→C, 4→E, 5→A
51. B — For every 1°C of warming, the atmosphere can hold about 7% more water vapor, leading to heavier rainfall events
52. D — Heat waves — they are the most clearly linked extreme event, with climate change making them 2-5 times more likely in many regions
53. D — Mitigation means reducing greenhouse gas emissions to slow climate change; adaptation means adjusting to the impacts that are already happening or expected
54. C — Warmer ocean surface temperatures provide more energy for storms, increasing the proportion of the strongest Category 4-5 hurricanes
55. C — Multiple climate hazards occurring simultaneously or in sequence, creating impacts worse than any single event alone
56. D — Higher baseline sea level means storm surges start from a higher point, so hurricane flooding reaches farther inland and causes more damage than the same storm would at historic sea levels
57. Higher temperatures and prolonged droughts dry out vegetation, creating more fuel for fires, while longer fire seasons extend the period of risk
58. A field that uses climate models and statistics to determine how much human-caused climate change contributed to the likelihood or intensity of a specific weather event
59. Rising temperatures, changing rainfall patterns, and more frequent extreme events reduce crop yields, while CO₂ can reduce nutritional quality of some crops
60. People forced to leave their homes due to climate impacts like sea level rise, drought, or extreme weather — projected to reach 200+ million by 2050
Matching (Climate Impacts & Extreme Weather): 1→A, 2→C, 3→D, 4→E, 5→B
61. B — Net-zero means the amount of greenhouse gases emitted equals the amount removed from the atmosphere, stabilizing atmospheric concentrations and halting further warming

62. A — Hydroelectric power — it accounts for about 15% of global electricity and over 50% of all renewable electricity generation
63. A — Photons from sunlight knock electrons loose in semiconductor materials (usually silicon), creating an electric current that flows through a circuit
64. A — Intermittency — the sun doesn't always shine and wind doesn't always blow, requiring energy storage or backup sources to maintain reliable power
65. D — Nuclear power generates large amounts of electricity with very low greenhouse gas emissions during operation, making it a reliable low-carbon baseload source
66. B — CCS captures CO₂ from industrial exhaust or power plants before it enters the atmosphere, then compresses and stores it underground in geological formations
67. Energy production (electricity and heat generation) at about 25%, followed closely by industry, transportation, and agriculture
68. Using less energy to provide the same service — like LED bulbs using 75% less electricity than incandescent for equal light — reduces total demand and therefore emissions
69. EVs produce zero tailpipe emissions and are 3-4 times more energy-efficient than combustion engines, but their climate benefit depends on how the electricity is generated and battery manufacturing impacts
70. Hydrogen produced by splitting water using renewable electricity (electrolysis) — it can replace fossil fuels in steelmaking, shipping, and aviation where direct electrification is impractical
Matching (Climate Solutions & Mitigation Strategies): 1→A, 2→B, 3→C, 4→D, 5→E
71. D — An international treaty signed by 196 countries in 2015 aiming to limit global warming to well below 2°C above pre-industrial levels, with efforts to limit it to 1.5°C
72. B — The Intergovernmental Panel on Climate Change — a UN body that assesses published climate science and produces reports that inform international policy decisions
73. B — Over 97% of actively publishing climate scientists agree that current warming is primarily caused by human activities — this represents one of the strongest consensus in modern science
74. B — NDCs are individual climate pledges each country sets for itself under the Paris Agreement — 'bottom-up' means each nation determines its own targets

based on its circumstances, rather than top-down mandated targets

75. B — False or misleading claims about climate science designed to delay action — identifiable by cherry-picking data, citing non-expert sources, logical fallacies, and contradiction of scientific consensus
76. B — 1998 was an exceptionally strong El Niño year (a natural spike); comparing any subsequent year to that peak ignores the clear long-term warming trend when all years are included
77. Public participation in scientific research — volunteers collect data (bird counts, weather observations, phenology records) that scientists use to track climate impacts at scales impossible for researchers alone
78. Wealthy industrialized nations produced most historical emissions that caused current warming, so climate justice argues they bear greater responsibility to cut emissions and fund adaptation in vulnerable nations that contributed least
79. Distress about climate change and its future impacts — productive channels include community action, citizen science participation, advocacy, learning solutions, and connecting with supportive peers
80. Weather forecasting predicts specific conditions at specific times (chaotic, limited to ~10 days); climate projection predicts average conditions over decades (driven by physics and energy balance, not daily chaos)
Matching (Climate Policy, Communication & Citizen Science Capstone): 1→D, 2→E, 3→A, 4→B, 5→C
81. D — Carbon dioxide
82. B — Carbon dioxide
83. B — The carbon cycle
84. B — Methane
85. A — The greenhouse effect
86. D — Rocks and sediments
87. CO₂ traps outgoing infrared radiation, preventing heat from escaping to space
88. It reduces the number of trees absorbing CO₂ and releases stored carbon when trees are burned or decay
89. Each methane molecule traps significantly more heat than a CO₂ molecule
90. They absorb CO₂ from the atmosphere, dissolving it in seawater and storing it in marine organisms

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

91. B — Analyzing trapped air bubbles to determine past atmospheric conditions and temperatures
92. D — A graph showing the continuous rise of atmospheric CO₂ measured at Mauna Loa Observatory since 1958
93. C — Past climate conditions including temperature and rainfall patterns for each year of the tree's life
94. C — Satellite imagery and radar measurements of ice sheet extent and thickness
95. B — Changes in sea level over time
96. A — An indirect source of climate data from natural archives like ice, sediments, or corals that preserves evidence of past conditions
97. Antarctic ice sheets are extremely old, with layers going back over 800,000 years, providing the longest continuous record of atmospheric composition
98. Corals incorporate different ratios of chemical elements into their skeletons depending on water temperature, creating annual growth bands
99. Multiple independent lines of evidence that agree strengthen confidence in conclusions and reduce the chance of error from any single source
100. It is the average of temperature measurements from thousands of stations worldwide, used because local temperatures vary greatly while the global average reveals overall trends

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

101. A — Solar energy
102. A — Carbon capture
103. C — Wind energy
104. C — The total amount of greenhouse gases produced by a person, organization, event, or product, expressed as CO₂-equivalent
105. B — A vehicle powered by electric motors using energy stored in rechargeable batteries instead of burning gasoline or diesel
106. A — Biomass energy
107. Because reducing energy waste is the cheapest and fastest way to lower emissions, often requiring no new technology
108. Solar panels generate electricity without burning fuel, producing no CO₂ during

operation, while coal plants release CO₂ by combusting fossil fuels

109. Because solar and wind energy are intermittent, producing electricity only when the sun shines or wind blows, so storage is needed to provide power at other times
110. A circular economy designs out waste by reusing, repairing, and recycling materials, reducing the emissions from manufacturing new products and disposing of old ones
Matching (Climate Science): 1→A, 2→E, 3→D, 4→C, 5→B
111. B — The Paris Agreement
112. A — Climate justice
113. B — Conference of the Parties
114. B — Greta Thunberg
115. D — Climate action plans that each country voluntarily submits outlining their specific targets for reducing greenhouse gas emissions
116. B — People who are forced to leave their homes due to climate change impacts such as rising sea levels, extreme weather, or prolonged droughts
117. Because even half a degree of additional warming could cause enough sea level rise to make many small islands uninhabitable, threatening their very existence as nations
118. Climate finance refers to funding from wealthier nations to help developing countries reduce emissions and adapt to climate impacts, recognizing that those who caused the most emissions should help those most affected
119. Climate change disrupts agriculture through droughts, floods, heat waves, and shifting seasons, threatening crop yields in regions that depend heavily on rain-fed farming and have fewer resources to adapt
120. Because countries that industrialized first produced the majority of cumulative greenhouse gases over centuries, creating the current crisis, while developing countries contributed far less but often suffer the worst impacts
Matching (Climate Science): 1→A, 2→E, 3→D, 4→C, 5→B
121. B — Weather describes short-term conditions, while climate describes long-term patterns over decades
122. B — A diagram with all five spheres connected by arrows showing how changes in one affect the others

123. C — Thermometer
124. A — Distance from the equator (latitude)
125. A — Helpful because it slows atmospheric warming, but concerning because it causes ocean warming that harms marine ecosystems and drives sea level rise
126. B — Good — without it, Earth would be too cold for liquid water and most life
127. Burning fossil fuels for electricity and transportation
128. A process where a change in one part of the climate system triggers further changes that either amplify or reduce the original change
129. Warm water causes corals to expel their symbiotic algae (bleaching), and prolonged bleaching kills the coral
130. Sea walls protect existing areas but are expensive, can fail, and may need constant upgrading; managed retreat avoids long-term risk but displaces communities and is politically difficult
Matching (Measuring Climate): 1→D, 2→C, 3→A, 4→E, 5→B
131. B — 30 years
132. A — The ocean absorbs and releases heat slowly, moderating the coastal city's temperature
133. A — Climate varies greatly by region, so global data requires measurements from everywhere
134. B — Temperature drops as altitude increases — higher elevations are colder regardless of latitude
135. A — Less heat escapes to space, so energy in exceeds energy out, and Earth warms until a new balance is reached
136. D — Human emissions are about 60 times greater than volcanic emissions, overwhelming the natural cycle's ability to absorb the excess
137. Warming → more wildfires → CO₂ released from burning trees → enhanced greenhouse effect → more warming (positive feedback loop)
138. About 71%
139. Initial warming was triggered by orbital changes, then warming released CO₂ from oceans, and the CO₂ amplified the warming — CO₂ was both a response and an amplifier
140. Multiple climate hazards occurring simultaneously or in sequence, creating

impacts worse than any single event alone

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

141. C — Satellites can observe the entire Earth, including oceans and remote areas with no weather stations
142. B — The surface absorbs it and converts it to heat, which is then radiated back toward space
143. B — The process where certain gases in Earth's atmosphere trap heat, keeping the planet warm
144. D — Thawing permafrost releases stored methane and CO₂, which causes more warming, which thaws more permafrost — a feedback loop
145. D — CO₂ warms the air → warmer air holds more water vapor → water vapor is a greenhouse gas → more warming → even more water vapor
146. A — Sea ice already displaces its weight in water while floating, so melting it doesn't add volume; land ice is new water entering the ocean
147. Rainfall amounts, temperature, and vegetation type above the cave — recorded in the minerals' chemical composition and growth rate
148. Shrinking sea ice reduces habitat for polar bears and penguins, permafrost thaw destabilizes terrain, and warming oceans disrupt food webs from krill to whales
149. Replace gas heating with electric heat pumps, install rooftop solar panels with battery storage, switch to LED lighting, improve insulation, and purchase remaining electricity from renewable sources
150. The global shift from fossil fuel-based energy systems to renewable and low-carbon sources — countries like Denmark, Iceland, Norway, and Costa Rica lead with 90%+ renewable electricity

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

151. D — 'Weather is your mood today; climate is your personality over your whole life'
152. C — Two jars with thermometers in sunlight — one sealed (representing atmosphere with greenhouse gases) and one open — measure temperature difference over time
153. B — A (electric car), C (lights), B (recycling paper) — transportation is the largest household emission source
154. C — Positive — warming thaws permafrost, releasing greenhouse gases, which causes more warming and more thawing

155. C — In the upper 700 meters (the top layer), though warming is now penetrating into deeper water
 156. B — No — sea level rise varies by region due to ocean currents, land subsidence, gravitational effects of ice sheets, and local geological factors
 157. Sea surface temperature, salinity, and ocean chemistry over the coral's lifetime — sometimes spanning centuries
 158. Warmer oceans evaporate more moisture, fueling long corridors of water vapor in the atmosphere that produce extreme rainfall when they make landfall
 159. High thin clouds trap heat (positive), while low thick clouds reflect sunlight (negative) — the net effect depends on cloud type
 160. A carbon price puts a monetary cost on each ton of CO₂ emitted, making polluting activities more expensive and clean alternatives more competitive
- Matching (Measuring Climate): 1→E, 2→A, 3→B, 4→C, 5→D
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