Terrawatch — Activity Book

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

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

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1. What Is Citizen Science?

Circle the correct answer

1. What is citizen science?
(A) When people watch science fiction movies for entertainment (B) When students take a science test at school (C) When only professional scientists do research in a laboratory (D) When ordinary people help scientists collect data and make observations

2. What is the main purpose of collecting data in citizen science?
(A) To gather information that helps scientists answer research questions (B) To fill out worksheets for a school assignment (C) To prove that only scientists can do research (D) To win prizes in a science competition

3. What tool do many citizen scientists use to record the date, time, and location of their observations?
(A) A television remote control (B) A pair of headphones (C) A kitchen blender (D) A field notebook or a digital data entry app

4. What does the word 'observation' mean in science?
(A) Making up a story about something you imagine (B) Copying someone else's homework word for word (C) Using your senses to carefully notice and describe something (D) Guessing an answer without looking at anything

5. Why do citizen science projects need data from many different people in many different places?
(A) Because scientists cannot be everywhere at once, and widespread data reveals larger patterns (B) Because having more people makes the project more fun at parties (C) Because scientists want to see who can collect data the fastest (D) Because data from one place is always wrong and useless

6. How is citizen science different from a regular school science experiment?
(A) School experiments are always more accurate than citizen science (B) Citizen science data contributes to real ongoing research used by professional scientists (C) Citizen science projects never follow the scientific method (D) Citizen science uses

completely different laws of physics

Write the answer

7. Why is it important for citizen scientists to follow specific instructions when collecting data?
Answer: _____

8. What happens to the data after citizen scientists submit their observations?
Answer: _____

9. Why do some citizen science projects ask participants to take photographs of what they observe?
Answer: _____

10. What does the term 'data quality' mean in citizen science?
Answer: _____

Match each question to its answer

1. Your class decides to count the number of butterflies visiting the school garden each week for a month. What should you record each time you observe? →
2. You find a bird you cannot identify during a citizen science bird count. What should you do? →
3. Your neighbor says citizen science data is not real science because regular people collected it. How would you respond using what you know? →
4. How would you set up a citizen science project to monitor frog populations in your neighborhood? →
5. You are training younger students to participate in a tree-counting citizen science project. What are the three most important skills to teach them? →

(A) Citizen science follows careful protocols and the data is verified by scientists, making it just as valid for research
(B) The date, time, weather conditions, number of butterflies, and species if known
(C) Record a detailed description of its appearance, behavior, and location, and note that the species is unknown
(D) How to accurately identify common trees, how to record data on the form, and why honest reporting matters
(E) Choose consistent observation times and locations, create a data recording sheet, and train all volunteers on frog identification

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2. Observing Nature

Circle the correct answer

11. What are the five senses that scientists use when making observations in nature?
(A) Guessing, wishing, hoping, dreaming, and imagining (B) Sight, hearing, smell, touch, and taste (C) Running, jumping, swimming, climbing, and flying (D) Reading, writing, drawing, painting, and singing

12. What is a field notebook used for in citizen science?
(A) Drawing pictures of your favorite cartoon characters (B) Writing fictional stories about imaginary animals (C) Keeping score during a soccer game on the field (D) Recording detailed observations, sketches, and measurements taken outdoors in nature

13. What does the term 'biodiversity' mean?
(A) The number of rocks and minerals in a mountain (B) The variety of different living things found in a particular area or on Earth (C) How tall the tallest building in a city is (D) A type of chemical used to clean swimming pools

14. What is a habitat?
(A) The natural environment where a plant or animal lives and finds what it needs to survive (B) The name of a board game about building houses (C) A habit that animals develop from watching television (D) A special type of hat worn by scientists in the laboratory

15. Why is it important to record the date and time when you make a nature observation?
(A) Because many animals and plants behave differently at different times and seasons, and timing helps scientists find patterns (B) Because plants and animals only exist at certain times of the day (C) Because scientists only accept observations made before lunchtime (D) Because the date makes your notebook look more organized but has no scientific value

16. How does sketching an organism in your field notebook help with scientific observation?
(A) Sketching is only useful if you plan to become a professional artist (B) Drawings always replace the need for written descriptions entirely (C) Scientists never draw anything because they only use computers (D) Drawing forces you to look closely at details you might otherwise miss, such as shape, color, and markings

Write the answer

17. What is the difference between an observation and an inference?
Answer: _____

18. Why do scientists use specific scientific names for organisms instead of just common names?
Answer: _____

19. What does it mean when scientists say an area has 'high biodiversity'?
Answer: _____

20. Why should you describe the weather conditions in your field notes when observing wildlife?
Answer: _____

Match each question to its answer

1. You are walking through a park and notice a bird singing from a tree but you cannot see it. How should you record this in your field notes? →
2. Your class is starting a nature observation journal. What information should the first page of each journal entry always include? →
3. You discover a plant you have never seen before during a nature walk. What steps should you take to document it for a citizen science project? →
4. Your teacher asks you to count the number of different tree species along your school's nature trail. How would you make sure your count is accurate? →
5. You are observing a squirrel in your backyard for a citizen science project. Write a proper observation using descriptive language instead of opinions. →

(A) Gray squirrel approximately 25 cm long, sitting on oak branch 3 meters high, holding and eating an acorn at 9:15 AM, sunny weather
(B) Photograph it from multiple angles, sketch it, note the location and habitat, measure its size, and describe its leaves, flowers, and stem
(C) Walk the entire trail systematically, use a field guide to identify species, mark each new species on a checklist, and recount to verify
(D) Note the date, time, location, describe the song as best you can, and record that the bird was heard but not visually identified
(E) Date, time, location, weather conditions, and the observer's name

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3. Data Collection Methods

Circle the correct answer

21. What is the purpose of using a standardized protocol in a citizen science project?
(A) To guarantee that every volunteer gets the exact same results (B) To ensure all volunteers collect data in the same way so results can be compared across locations and time periods (C) To make the project more complicated and confusing for

volunteers (D) To prevent volunteers from using any creativity during data collection

22. What is a transect in ecological field research?
(A) A type of insect that lives in tropical rainforests (B) A special tent that scientists sleep in during field expeditions (C) A mathematical formula used to calculate the age of fossils (D) A straight line or path along which organisms or environmental conditions are recorded at regular intervals

23. What is a quadrat used for in ecological sampling?
(A) A square frame placed on the ground to count and identify all organisms within a defined area (B) A four-wheeled vehicle used to transport scientists to remote locations (C) A square-shaped aquarium for keeping fish in a laboratory (D) A type of graph paper used only for mathematics homework

24. What does 'sampling' mean in scientific data collection?
(A) Tasting small pieces of food at a grocery store (B) Copying answers from another student's test paper (C) Studying a smaller portion of a population or area to make estimates about the whole (D) Playing a short clip of a song on the radio

25. Why is it important to measure exactly the same way each time you collect data?
(A) Consistent measurements make your notebook look neater (B) Because scientists will be angry if you use a different ruler (C) Consistent measurement methods ensure that differences in data reflect real changes in nature, not differences in how you measured (D) It does not actually matter — any measurement method gives the same results

26. What is the difference between qualitative and quantitative data?
(A) Quantitative data uses words and qualitative data uses numbers (B) Qualitative data is always better than quantitative data in every situation (C) Qualitative data describes qualities or characteristics using words, while quantitative data uses numbers and measurements (D) There is no real difference — both terms mean the same thing

Write the answer

27. Why do scientists take multiple measurements of the same thing instead of just one?
Answer: _____

28. What is the advantage of using GPS coordinates instead of a written location description when recording where you made an observation?
Answer: _____

29. What is meant by 'random sampling' in ecological research?
Answer: _____

30. Why is it important to record what you did NOT find during a field survey, not just what you did find?

Answer: _____

Match each question to its answer

1. Your citizen science project requires you to measure the diameter of tree trunks. You only have a flexible measuring tape. How would you determine the diameter of a round trunk? →
2. You are setting up quadrat sampling to estimate wildflower density in a meadow. The meadow is 100 meters by 50 meters. How would you place your quadrats to get a representative sample? →
3. Your team is collecting water temperature data at a stream every week. You notice that last week's reading seems unusually high. What steps should you take before recording it? →
4. You need to estimate the number of dandelions growing in your school's sports field. The field is too large to count every single plant. Design a sampling method. →
5. A citizen science app asks you to record the percent cloud cover during your observation session. How would you estimate this? →

(A) Divide the field into a grid, randomly select 15-20 grid squares, count all dandelions in each square, calculate the average per square, and multiply by total squares to estimate the population

(B) Mentally divide the sky into quarters or eighths, estimate how many sections are covered by clouds, and convert to a percentage

(C) Use a random number generator to select grid coordinates, place at least 10-20 quadrats at those random locations, and count all wildflowers within each frame

(D) Wrap the tape around the trunk to measure the circumference, then divide by pi (approximately 3.14) to calculate the diameter

(E) Verify the thermometer is working correctly, take the measurement again, check if conditions were unusual that day, and record the value with a note about the anomaly

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4. Ecosystems & Habitats

Circle the correct answer

31. What is an ecosystem?

(A) A building where scientists store their laboratory equipment (B) A single plant growing alone in a pot on a windowsill (C) A community of living organisms interacting with each other and their nonliving environment in a specific area (D) A

type of technology used to recycle plastic bottles

32. What is a habitat?
(A) The specific natural environment where a particular species lives and finds the resources it needs to survive (B) A type of food that all animals eat regardless of species (C) The name for any animal that lives in a zoo enclosure (D) A scientific instrument used to measure temperature underground

33. What is a food web?
(A) A single straight line showing one animal eating one plant (B) A diagram showing the complex network of feeding relationships among multiple species in an ecosystem (C) A net made of food that fishermen use to catch fish (D) A website where people order groceries for delivery

34. What is the role of a producer in an ecosystem?
(A) Producers are organisms like plants and algae that make their own food from sunlight through photosynthesis, providing energy for the entire food web (B) Producers are animals that eat other animals to get their energy (C) Producers are mushrooms that break down dead organisms into soil nutrients (D) Producers are bacteria that cause diseases in plants and animals

35. Why do citizen scientists monitor the types of plants growing in different habitats?
(A) Because plant species indicate habitat health and environmental conditions, and changes in plant communities signal ecosystem shifts (B) Because plants never change so the data always stays the same year after year (C) Because scientists want to build the world's largest plant collection in a museum (D) Because counting plants is easier than doing real scientific research

36. How does energy flow through a food web?
(A) Energy flows from producers to primary consumers to secondary consumers, with energy decreasing at each level because organisms use energy for their own life processes (B) Energy increases at each level so top predators have the most energy (C) Energy flows equally in all directions with no loss at any level (D) Energy only exists in decomposers and does not flow through other organisms

Write the answer

37. What happens to an ecosystem when a keystone species is removed?
Answer: _____

38. Why are wetlands often called the most productive ecosystems on Earth?
Answer: _____

39. What is the difference between a biotic factor and an abiotic factor in an ecosystem?

Answer: _____

40. Why is it important for citizen scientists to record not only what species they observe but also the habitat conditions at the observation site?

Answer: _____

Match each question to its answer

1. You are conducting a habitat survey in a local forest. You notice the understory has very few plants compared to a nearby forest. What environmental factors should you investigate to explain this difference? →
2. A citizen science project asks you to classify habitats along a river. You find an area where the riverbank transitions from open water to mud flats to grassy meadow. How would you classify and document this zone? →
3. You discover an invasive plant species during a citizen science habitat survey. What steps should you take to properly document and report this finding? →
4. Your citizen science team is monitoring a local pond ecosystem. Design a simple food web diagram based on these organisms: algae, mosquito larvae, dragonfly nymphs, tadpoles, frogs, and a great blue heron. →
5. You need to compare the biodiversity of two different habitats for a citizen science project: a mowed lawn and a wildflower meadow. How would you design a fair comparison study? →

(A) As a riparian transition zone with multiple microhabitats, recording distinct vegetation and soil conditions at each stage from water's edge to upland meadow

(B) Light levels reaching the forest floor, soil moisture and nutrients, canopy density, and whether deer or other herbivores are overbrowsing the understory

(C) Algae is eaten by mosquito larvae and tadpoles; dragonfly nymphs eat mosquito larvae; tadpoles grow into frogs; frogs eat dragonfly nymphs; the heron eats frogs — showing energy flowing from producers through multiple consumer levels

(D) Photograph the plant, record its exact GPS location, note the estimated coverage area and surrounding native species, and report it to the project coordinator immediately

(E) Use identical sampling methods in both habitats — same number of quadrats, same size, same time of day, same season — and count all species of plants and insects found in each

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5. Weather & Climate Monitoring

Circle the correct answer

41. What is the difference between weather and climate?
(A) Weather and climate are the same thing and can be used interchangeably (B) Weather describes short-term atmospheric conditions at a specific time and place, while climate describes the long-term average of weather patterns in a region over decades (C) Weather lasts exactly one year while climate lasts exactly one day (D) Climate only applies to tropical regions while weather applies everywhere else

42. What instrument measures atmospheric pressure?
(A) A thermometer (B) An anemometer (C) A rain gauge (D) A barometer

43. What does a rain gauge measure?
(A) The total amount of water in nearby rivers and lakes (B) The speed at which raindrops fall from the clouds (C) The temperature of rainwater compared to groundwater (D) The amount of liquid precipitation that falls over a specific time period, measured in millimeters or inches

44. What is the purpose of the CoCoRaHS citizen science network?
(A) CoCoRaHS trains people to become professional television meteorologists, making this the most widely accepted explanation (B) CoCoRaHS recruits volunteers across the United States to measure and report daily precipitation, creating a dense network of rainfall data that fills gaps between official weather stations (C) CoCoRaHS sells rain gauge equipment to hardware stores for profit, and this is the standard approach used in most cases (D) CoCoRaHS is a social media platform for sharing photos of rainbows, and this has been consistently demonstrated in practice

45. Why is it important that citizen scientists read their weather instruments at the same time each day?
(A) Because scientists want to control when people wake up in the morning (B) Because weather instruments only work at one specific time of day (C) Consistent timing ensures that measurements cover the same 24-hour period, making data comparable between days and between different observers across the network (D) Because temperature and rainfall only occur at one time of day

46. How do citizen scientists contribute to our understanding of urban heat islands?
(A) By planting tropical flowers in every urban garden to increase humidity, which is the most common explanation for this phenomenon (B) By recording temperatures at many locations across cities, volunteers reveal how paved surfaces, buildings, and lack of vegetation create areas significantly warmer than surrounding rural areas (C) By painting buildings white to reflect sunlight away from the city, which is the most common explanation for this phenomenon (D) By measuring ocean temperatures from boats in the harbor, which is why this approach is recommended by experts

Write the answer

47. What is phenology and why is it important for climate monitoring?
Answer: _____

48. Why do scientists need weather data from thousands of citizen scientists instead of relying only on official weather stations?
Answer: _____

49. How does recording the first frost date each autumn contribute to climate research?
Answer: _____

50. What role do clouds play in the Earth's energy balance, and why does NASA's GLOBE Observer program ask citizen scientists to photograph clouds?
Answer: _____

Match each question to its answer

1. You are setting up a personal weather station for a citizen science project. Where should you place your thermometer to get the most accurate air temperature reading? →
2. Your citizen science project asks you to classify cloud types. You observe high, thin, wispy clouds that let sunlight through. What cloud type would you report, and what weather might it suggest? →
3. After a heavy rainstorm, your citizen science rain gauge shows 2.5 inches of precipitation but the official weather station 8 miles away reports only 0.3 inches. How should you handle this discrepancy when reporting your data? →
4. You want to determine whether spring is arriving earlier in your area compared to 20 years ago. What phenological observations should you track, and how would you compare your data to historical records? →
5. Your school wants to participate in the GLOBE Program's surface temperature protocol. Design a data collection plan that includes what to measure, when to measure, and how to ensure data quality. →

(A) Track first bloom dates of native plants, first bird migration arrivals, and first frog calls each spring, then compare your dates to historical records from local nature societies, agricultural extensions, or citizen science databases like Nature's Notebook
(B) Cirrus clouds — these high-altitude ice crystal clouds often indicate fair weather currently but may signal an approaching warm front and precipitation within 24-48 hours
(C) In a shaded, ventilated location about 5 feet above ground, away from buildings, pavement, and other surfaces that absorb and radiate heat

(D) Measure surface temperature, air temperature, cloud cover, and current weather conditions at the same time daily using calibrated instruments, with at least two students independently reading each instrument to cross-check accuracy
(E) Report your measurement accurately with notes about the storm's localized nature — convective storms can produce dramatically different rainfall amounts over short distances, and your observation captures what the official station missed

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6. Water Quality & Conservation

Circle the correct answer

51. What is a watershed?
(A) A building where water is stored in large tanks for city use (B) A machine that purifies drinking water by removing bacteria (C) A type of dam that prevents rivers from flooding during storms (D) An area of land where all precipitation drains into a common body of water such as a river, lake, or ocean

52. What does dissolved oxygen (DO) measure in water quality testing?
(A) The total weight of all water molecules in a stream (B) The temperature of oxygen atoms compared to hydrogen atoms in water molecules (C) The number of oxygen tanks stored at a nearby scuba diving shop (D) The amount of oxygen gas dissolved in the water, which aquatic organisms like fish and insects need to breathe

53. What is pH and what does it measure in a water sample?
(A) pH stands for 'pure hydrogen' and measures how clean drinking water is (B) pH measures how acidic or basic a water sample is on a scale from 0 to 14, with 7 being neutral, below 7 being acidic, and above 7 being basic (C) pH measures the speed at which water flows through a pipe (D) pH measures the color of water on a scale from 0 to 100

54. What are macroinvertebrates and why are they used as bioindicators of water quality?
(A) Macroinvertebrates are types of rocks found on riverbeds that change color when water is polluted, as this is what research and standard practice suggests (B) Macroinvertebrates are small animals without backbones visible to the naked eye — like mayfly larvae, caddisfly larvae, and snails — that are used as bioindicators because different species have different pollution tolerances, so the community present reveals water quality (C) Macroinvertebrates are microscopic bacteria that can only be seen with electron microscopes, making this the most widely accepted explanation (D) Macroinvertebrates are large mammals that drink from streams and are unaffected by pollution, as this is what research and standard practice suggests

55. What is the main difference between point source pollution and nonpoint source pollution in waterways?
(A) There is no difference — all water pollution comes from the same single source (B) Point source pollution only affects one point on a map while nonpoint source pollution affects the entire planet equally (C) Point source pollution is always visible as colored water while nonpoint source pollution is always invisible (D) Point source pollution comes from a single identifiable location like a factory pipe or sewage outfall, while nonpoint source pollution comes from many diffuse sources spread across the landscape like agricultural runoff, lawn fertilizers, and road salt

56. Why does water temperature matter for aquatic ecosystems?
(A) Water temperature does not affect aquatic life because fish can survive at any temperature (B) Water temperature controls dissolved oxygen levels, metabolic rates of aquatic organisms, and reproductive timing — warmer water holds less oxygen and stresses cold-water species (C) Warm water is always better for ecosystems because it makes organisms grow faster (D) Water temperature only matters for swimming pools and has no ecological significance

Write the answer

57. How does excess nitrogen and phosphorus from fertilizer runoff affect freshwater ecosystems?
Answer: _____

58. What is turbidity and why do citizen scientists measure it?
Answer: _____

59. Why are riparian buffer zones along streams and rivers important for water quality?
Answer: _____

60. What is the difference between surface water and groundwater, and why does contamination of one affect the other?
Answer: _____

Match each question to its answer

1. You are conducting a stream health assessment for a citizen science project. You find abundant mayfly larvae, stonefly larvae, and caddisfly larvae in your water sample. What does this community tell you about the water quality? →
2. During a citizen science water monitoring event, you test a stream upstream and downstream of a parking lot. Upstream pH is 7.2, dissolved oxygen is 9 mg/L, and water is clear. Downstream pH is 6.5, dissolved oxygen is 6 mg/L, and water is cloudy. What actions should you take to document this change? →

3. Your community reports fish kills in a local lake every August. As a citizen scientist, design a monitoring plan to identify the cause. Specify what parameters to test, when and where to sample, and what patterns might reveal the cause. →
4. A new housing development is being built on a hillside above your local creek. As a citizen scientist, what water quality measurements should you take before, during, and after construction to document any impacts? →
5. You have been asked to train younger students to use water quality test kits for a citizen science stream monitoring project. Design a training session that covers the essential skills and safety procedures. →

(A) The water quality is excellent — mayfly, stonefly, and caddisfly larvae are highly sensitive to pollution and only thrive in clean, well-oxygenated water, so their abundance indicates a healthy aquatic ecosystem
(B) Teach proper test kit calibration and use, demonstrate correct sample collection technique (facing upstream, avoiding disturbing sediment), explain safety rules (never drink stream water, wear gloves, wash hands), practice reading results accurately, and have each student perform supervised test runs before recording real data
(C) Before construction, establish baseline measurements of turbidity, sediment load, dissolved oxygen, pH, macroinvertebrate community, and streambank stability — during construction, monitor weekly for increased turbidity and sediment — after construction, compare all parameters to baseline to document recovery or persistent damage
(D) Record all measurements with exact GPS locations, photograph both sites, note the parking lot as a potential pollution source, estimate its size and drainage direction, and submit the comparison data to the project coordinator as evidence of a possible nonpoint source impact
(E) Test dissolved oxygen, temperature, nutrient levels (nitrogen and phosphorus), algal density, and pH at multiple depths and locations weekly from June through September — the pattern to look for is a summer algal bloom depleting dissolved oxygen in deeper water as temperatures peak, creating a lethal combination of low oxygen and high temperature

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7. Biodiversity & Species Identification

Circle the correct answer

61. What is taxonomy?
(A) The study of how to file income taxes and government financial documents, which is why this approach is recommended by experts (B) A branch of mathematics that calculates the distance between stars, making this the most widely accepted explanation (C) The art of mounting animals for museum displays, which is why this

approach is recommended by experts (D) The science of classifying and naming organisms based on shared characteristics and evolutionary relationships, organized into hierarchical groups from domain to species

62. What is a dichotomous key?
(A) A musical key signature that uses only two notes in a composition, and this is the standard approach used in most cases (B) A type of computer password that requires two different numbers, making this the most widely accepted explanation (C) A physical key that opens two different locks simultaneously, and this principle applies across similar situations (D) An identification tool that uses a series of paired choices about observable characteristics to guide the user step by step to the correct species identification

63. What is biodiversity?
(A) The number of zoos and aquariums in a country, which is the most common explanation for this phenomenon (B) The total number of individual organisms without regard to how many different species exist, as this is what research and standard practice suggests (C) A measurement of how colorful animals are in a rainforest habitat, which is the most common explanation for this phenomenon (D) The variety of all living organisms in a given area, measured at three levels: genetic diversity within species, species diversity within communities, and ecosystem diversity across landscapes

64. What is the scientific naming system called that gives every species a unique two-part Latin name?
(A) The nickname system — scientists vote on the most popular common name (B) The numbering system — each species receives a unique barcode number instead of a name (C) Binomial nomenclature — the first word is the genus and the second is the specific epithet, written in italics with the genus capitalized (D) The alphabet system — species are named using single random letters

65. Why is accurate species identification important for citizen science biodiversity surveys?
(A) Citizen scientists should not attempt identification because only PhDs can tell species apart (B) Identification accuracy does not matter because all species are essentially the same (C) Species identification is only important for rare species and common species can be lumped together (D) Because misidentified species corrupt datasets, produce inaccurate population estimates, and can lead to wrong conservation decisions — accurate identification is the foundation of all biodiversity data

66. How do morphological characteristics differ from genetic characteristics in species identification?

(A) Morphological characteristics are observable physical features like shape, size, color, and structure that can be seen directly, while genetic characteristics are DNA sequences that reveal evolutionary relationships and can distinguish cryptic species that look identical (B) Morphological and genetic characteristics always give the same identification results for every organism, as this is what research and standard practice suggests (C) Genetic characteristics can only be studied on extinct species using fossils, and this has been consistently demonstrated in practice (D) Morphological characteristics are more accurate than genetic analysis in every case, which is the most common explanation for this phenomenon

Write the answer

67. What is the purpose of a species abundance survey versus a species richness survey?

Answer: _____

68. How does the citizen science platform iNaturalist use artificial intelligence to help with species identification?

Answer: _____

69. What is environmental DNA (eDNA) and why is it revolutionary for biodiversity surveys?

Answer: _____

70. What is the difference between endemic species and invasive species, and why does this distinction matter for conservation?

Answer: _____

Match each question to its answer

1. You discover a plant during a citizen science BioBlitz that you cannot identify using your field guide. The plant has alternate, simple leaves with toothed margins and small white flowers in a flat-topped cluster. Demonstrate how you would systematically document this observation for later expert identification. →
2. You are leading a bird point count survey at a local park. Explain how you would use a dichotomous approach to identify a small brown bird you observe foraging on the ground near a thicket. →
3. Your citizen science team is planning a BioBlitz — a 24-hour intensive biodiversity survey. Design the survey strategy, including how you would divide habitats, assign specialists, coordinate teams, and ensure comprehensive coverage. →
4. You are training fellow students to use iNaturalist for a school biodiversity

monitoring project. Create a guide explaining how to take photos that maximize the chance of getting an accurate AI identification and community verification. →
5. A citizen science forest inventory found that a plot contained 5 species of oak trees (genus Quercus). Species A had 200 individuals, Species B had 3, Species C had 150, Species D had 45, and Species E had 2. Calculate the species richness and discuss what the abundance distribution reveals about the forest community. →

(A) Species richness is 5 (five distinct species). The abundance distribution is highly uneven — Species A and C dominate (87.5% of individuals), while Species B and E are extremely rare (1.25% combined) — this suggests the dominant species are well-adapted to local conditions while rare species may be at the edge of their range, recently colonizing, or declining
(B) Systematically narrow identification by observing: size relative to known species, bill shape (seed-cracking vs. insect-probing), tail behavior (bobbing, flicking, fanning), breast markings (streaked, spotted, plain), wing bars, eye ring, habitat preference, and foraging behavior — each observation eliminates groups of species until one remains
(C) Divide the survey area into distinct habitat zones (forest, wetland, meadow, stream), assign taxonomic specialists to each zone (birders, botanists, entomologists, herpetologists), schedule nocturnal surveys for night-active species, create standardized data recording forms, establish a central identification station for difficult specimens, and coordinate timing to avoid disturbing wildlife across adjacent zones
(D) Photograph each organism from multiple angles showing diagnostic features: overall form, close-up of key identifying structures (flowers, leaves, wings, antennae), scale reference, and habitat context — ensure sharp focus, good lighting, and avoid shooting against bright sky; include a note on any features photos cannot capture like sound, texture, or movement patterns
(E) Photograph the whole plant, a single leaf showing both surfaces, a close-up of the flower cluster, the stem cross-section, and the habitat context — record GPS coordinates, date, habitat type, associated species, plant height, and any notable scent or texture, then upload with all details to iNaturalist for expert review

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8. Research Design & Data Analysis

Circle the correct answer

71. What is a scientific hypothesis?
(A) A random guess about something that cannot be tested or measured, and this principle applies across similar situations (B) A proven fact that all scientists have already agreed is true, as this directly follows from the underlying principles (C) An opinion about which animal is the most interesting to study, as this is what research

and standard practice suggests (D) A testable, falsifiable prediction about the relationship between variables, based on observations and prior knowledge, that can be supported or rejected through systematic data collection

72. What is the difference between an independent variable and a dependent variable in an experiment?
(A) The independent variable is the factor the researcher deliberately changes or compares across groups, while the dependent variable is the outcome being measured that may change in response to the independent variable (B) Independent variables can only be used in physics while dependent variables can only be used in biology (C) Both terms mean the same thing and are used interchangeably in scientific research (D) Independent variables are measured last and dependent variables are measured first

73. What is a control group and why is it essential in experimental design?
(A) A control group receives no treatment or a standard treatment, providing a baseline against which the effects of the experimental treatment can be compared — without a control, it is impossible to know whether observed changes were caused by the treatment or by other factors (B) A control group is the group that controls the entire experiment and tells other groups what to do, which is the most common explanation for this phenomenon (C) Controls are optional and only used in experiments that have unlimited funding, which is the most common explanation for this phenomenon (D) A control group always receives the strongest dose of the treatment being tested, which is why this approach is recommended by experts

74. What is the purpose of replication in scientific research?
(A) Scientists replicate to waste time and make experiments take longer than necessary, and this has been consistently demonstrated in practice (B) Replication means repeating measurements or experiments multiple times to determine whether results are consistent and reliable — it helps distinguish real effects from random variation and increases statistical confidence in conclusions (C) Replication means copying another scientist's published paper word for word, and this principle applies across similar situations (D) Replication is only needed when the first experiment produces unexpected results, and this is the standard approach used in most cases

75. What is sampling bias and how can it affect the results of a citizen science study?
(A) Bias means the scientist intentionally lied about their results, as this is what research and standard practice suggests (B) Sampling bias occurs when data is collected in a way that systematically overrepresents or underrepresents certain populations, locations, or conditions — in citizen science, this often means more data from accessible, populated areas and less from remote or underserved areas, skewing conclusions (C) Sampling bias improves data quality by focusing observations on the most important areas, as this is what research and standard practice suggests (D) Sampling bias only occurs in laboratory experiments and cannot happen in citizen

science fieldwork, making this the most widely accepted explanation

76. Why is it important to distinguish between correlation and causation when analyzing citizen science data?
(A) Correlation is unscientific and should never be reported in research findings, making this the most widely accepted explanation (B) Causation can be established from any dataset regardless of experimental design, and this has been consistently demonstrated in practice (C) Correlation means two variables change together, but causation means one variable directly causes the other to change — confusing the two can lead to incorrect conclusions because correlated variables may both be influenced by a third unmeasured factor (D) Correlation and causation are the same concept expressed using different vocabulary, and this principle applies across similar situations

Write the answer

77. What is a confounding variable and how can it compromise the validity of a research study?
Answer: _____

78. What does the term 'sample size' mean and why does it matter for the reliability of citizen science research?
Answer: _____

79. What is the purpose of data visualization in communicating citizen science results?
Answer: _____

80. What is peer review and why is it important for validating citizen science research before it is published?
Answer: _____

Match each question to its answer

1. A citizen science project hypothesizes that bird species richness decreases with distance from protected forests. Design a study to test this hypothesis, including your sampling strategy, variables, controls, and how you would account for potential confounding factors. →
2. Your citizen science team collected water temperature data from 50 stream sites once per month for 12 months. Create a data analysis plan describing how you would organize, clean, visualize, and analyze this dataset to identify temperature patterns across seasons and sites. →
3. You need to determine whether a rain garden installed at your school is actually reducing the amount of sediment reaching a nearby stream. Design an experiment with clear independent and dependent variables, controls, replication, and a timeline.

→

4. A citizen science project tracked butterfly abundance in meadows across your state. They found that meadows mowed in late autumn had 60% more butterfly species the following summer than meadows mowed in early summer. However, the autumn-mowed meadows were also located at higher elevations with cooler temperatures. Identify the confounding variable and explain how you would redesign the study to isolate the mowing timing effect. →

5. Your citizen science project collected 3 years of weekly bird count data from 25 sites. You want to present findings to the community. Choose the most appropriate type of graph for each of the following analyses: (1) showing how total bird numbers changed across seasons, (2) comparing species richness among habitat types, and (3) showing the relationship between distance from water and bird abundance. →

(A) Organize data in a spreadsheet with columns for site ID, date, GPS coordinates, temperature, and habitat characteristics; clean by flagging outliers and checking for recording errors; visualize with time series plots showing monthly trends per site, box plots comparing seasonal distributions, and a heat map showing temperature by site and month; analyze with summary statistics per site and season, and correlation analysis comparing temperatures between upstream and downstream sites

(B) Elevation and temperature are confounding variables because they correlate with both the mowing timing (the independent variable) and butterfly diversity (the dependent variable). Redesign by selecting pairs of meadows at the same elevation where one receives autumn mowing and the other receives summer mowing, ensuring that elevation, soil type, surrounding habitat, and meadow size are matched between pairs, so the only systematic difference is mowing timing

(C) (1) Line graph with months on the x-axis showing seasonal trends in total counts over time. (2) Box-and-whisker plot with habitat types on the x-axis showing the distribution and median species richness for each habitat. (3) Scatter plot with distance from water on the x-axis and bird abundance on the y-axis, revealing any correlation between the two variables

(D) Independent variable: presence/absence of rain garden (before installation vs. after, or rain garden site vs. comparable site without one). Dependent variable: sediment concentration in stream water (measured by turbidity meter) after rain events. Control: a comparable section of stream that does not receive rain garden runoff. Replication: measure after at least 10 rain events of similar intensity at both sites. Timeline: collect baseline data for 3 months before installation, then monitor for 12 months after installation, always sampling within 2 hours of rain event onset

(E) Establish bird survey points at standardized distances from the forest edge (0m, 100m, 500m, 1km, 2km, 5km), with 5 replicate points at each distance in similar habitat types, conduct 10-minute point counts at each site monthly for one year, control for habitat type and elevation by selecting sites with similar characteristics at each distance, and account for confounds like urbanization level, local vegetation density,

and observer skill by recording these covariates for statistical analysis

9. Nature Observation

Circle the correct answer

81. What is the scientific study of birds called?
(A) Entomology (B) Ornithology (C) Ichthyology (D) Herpetology

82. What type of feather provides the main lifting surface on a bird's wing?
(A) Flight feather (remige) (B) Contour feather (C) Filoplume (D) Down feather

83. What term describes birds that migrate to warmer regions for winter?
(A) Migratory birds (B) Invasive birds (C) Resident birds (D) Vagrant birds

84. Which bird sense is generally considered the most important for finding food?
(A) Vision (B) Touch (C) Hearing (D) Smell

85. What is the hard, outer covering of a bird's beak made of?
(A) Keratin (B) Chitin (C) Calcium carbonate (D) Bone

86. What is a group of birds flying together called?
(A) A school (B) A flock (C) A pack (D) A herd

Write the answer

87. Why do woodpeckers have a thick skull and spongy bone structure?
Answer: _____

88. Why do many male birds have brighter plumage than females?
Answer: _____

89. What does the shape of a bird's beak tell you about its diet?
Answer: _____

90. Why do birds sing most actively at dawn (the 'dawn chorus')?
Answer: _____

Match each question to its answer

1. How does the V-formation help migrating geese conserve energy? →
2. You observe a bird with a long, thin, slightly curved beak probing into flowers. What is this bird most likely eating? →
3. While birdwatching, you see a raptor soaring in wide circles without flapping its

wings. What is this bird using to stay aloft? →
4. You find a bird nest on the ground made of grasses and lined with feathers, located in an open meadow. Which type of bird most likely built it? →
5. You notice a small bird repeatedly diving at a much larger hawk. What behavior is this bird displaying? →

(A) Thermals (rising columns of warm air)
(B) Mobbing behavior to drive a predator away from its nest
(C) A ground-nesting bird like a killdeer or meadowlark
(D) Each bird flies in the updraft created by the wingtip of the bird ahead, reducing air resistance
(E) Nectar

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10. Nature Observation

Circle the correct answer

91. What does pH measure in water?
(A) How fast the water flows (B) How much oxygen is dissolved in it (C) How acidic or basic the water is (D) How warm the water is

92. What is the term for the amount of oxygen dissolved in water?
(A) Dissolved oxygen (DO) (B) Water saturation (C) Oxygen density (D) Air content

93. What are macroinvertebrates?
(A) Fish with no scales, as this is what research and standard practice suggests (B) Animals without backbones that are large enough to see without a microscope (C) Plants that grow in streams, which is the most common explanation for this phenomenon (D) Tiny bacteria in water, which is why this approach is recommended by experts

94. What is a watershed?
(A) A building where water is stored, and this has been consistently demonstrated in practice (B) A machine that purifies water, and this is the standard approach used in most cases (C) A dam that holds back water, which is why this approach is recommended by experts (D) An area of land where all water drains to a common outlet like a river, lake, or ocean

95. What type of pollution comes from a single, identifiable source like a factory pipe?
(A) Nonpoint source pollution (B) Thermal pollution (C) Natural pollution (D) Point source pollution

96. What is the name for tiny, often microscopic organisms that drift in water and form the base of aquatic food chains?
(A) Benthos (B) Plankton (C) Nekton (D) Detritus

Write the answer

97. Why does warm water typically hold less dissolved oxygen than cold water?
Answer: _____

98. Why are mayfly larvae considered good indicators of high water quality?
Answer: _____

99. How does excess nitrogen and phosphorus from fertilizer runoff cause fish kills in lakes?
Answer: _____

100. Why does riparian vegetation (plants along stream banks) improve water quality?
Answer: _____

Match each question to its answer

1. What is the relationship between turbidity and aquatic plant growth? →
2. You test a stream and find a pH of 4.2. What is the most likely cause and what effect would this have on aquatic life? →
3. You are choosing a site to test water quality in a creek. Why should you collect samples upstream AND downstream of a suspected pollution source? →
4. After heavy rain, you notice a stream is brown and muddy. What water quality parameter has changed the most? →
5. You find many tubifex worms and rat-tailed maggots but no mayfly or stonefly larvae in a stream sample. What does this tell you about water quality? →

(A) Comparing upstream and downstream samples shows whether the suspected source is actually changing water quality
(B) The water quality is poor because only pollution-tolerant organisms are present
(C) High turbidity reduces light penetration, limiting photosynthesis by underwater plants
(D) Acid rain or mine drainage has made the water very acidic, which would kill or drive away most aquatic organisms
(E) Turbidity (the water has become much cloudier due to sediment runoff)

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11. Nature Observation

Circle the correct answer

101. What instrument measures atmospheric pressure?
(A) Thermometer (B) Anemometer (C) Hygrometer (D) Barometer

102. What are the three main types of clouds based on altitude?
(A) Tornado, hurricane, and thunderstorm (B) Fog, mist, and haze (C) Cirrus (high), altostratus (middle), and stratus/cumulus (low) (D) Rain, snow, and hail

103. What does an anemometer measure?
(A) Wind speed (B) Cloud height (C) Humidity level (D) Rainfall amount

104. What is the dew point?
(A) The temperature at which snow melts (B) The temperature at which water boils (C) The temperature at which air becomes saturated and water vapor begins to condense (D) The coldest temperature recorded in a day

105. What is the boundary between two different air masses called?
(A) A front (B) A jet stream (C) An isobar (D) A pressure system

106. What unit is most commonly used to measure rainfall?
(A) Degrees Celsius (B) Kilometers per hour (C) Hectopascals (D) Millimeters (or inches)

Write the answer

107. Why does air pressure decrease as altitude increases?
Answer: _____

108. Why do clouds form when warm, moist air rises?
Answer: _____

109. How does a cold front typically produce different weather than a warm front?
Answer: _____

110. Why do coastal areas tend to have milder temperatures than inland areas at the same latitude?
Answer: _____

Match each question to its answer

1. What causes the Coriolis effect and how does it influence weather patterns? →
2. You check the barometer and notice pressure has been dropping steadily over the past 6 hours. What weather should you expect? →
3. You observe tall, dark cumulonimbus clouds building in the west on a summer

afternoon. What should you prepare for? →
4. The forecast calls for a dew point of 22 degrees Celsius. How will the air feel to you? →
5. You are setting up a school weather station. Where should you place the thermometer for accurate readings? →

(A) In a ventilated shelter (Stevenson screen) about 1.5 meters above the ground, away from buildings and pavement
(B) Very humid and uncomfortable — a dew point above 20 degrees C feels oppressive to most people
(C) Thunderstorms with possible lightning, heavy rain, gusty winds, and potentially hail
(D) Worsening weather, likely clouds, rain, or a storm approaching
(E) Earth's rotation causes moving air to curve, deflecting winds to the right in the Northern Hemisphere and left in the Southern Hemisphere

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12. Nature Observation

Circle the correct answer

111. What is citizen science?
(A) An app for sharing science news, and this is the standard approach used in most cases (B) Science performed only by government employees, as this is what research and standard practice suggests (C) Scientific research conducted with participation from the general public, often in data collection or observation (D) A type of social studies class, and this is the standard approach used in most cases

112. What is a transect in field ecology?
(A) A straight line along which organisms or environmental conditions are recorded at regular intervals (B) A circular plot used for tree measurements, as this directly follows from the underlying principles (C) A net used to catch insects, and this has been consistently demonstrated in practice (D) A type of soil sample, as this is what research and standard practice suggests

113. What is a quadrat used for in field surveys?
(A) A type of camera trap, which is the most common explanation for this phenomenon (B) A square frame placed on the ground to count organisms within a defined area (C) A device for testing water pH, and this has been consistently demonstrated in practice (D) A tool for measuring wind speed, which is the most common explanation for this phenomenon

114. What does the term 'biodiversity' mean?
(A) How fast organisms reproduce, which is the most common explanation for this phenomenon (B) The variety of life in a particular area, including the number of species and their relative abundance (C) The total number of individual organisms in one species, as this is what research and standard practice suggests (D) The weight of all organisms in an area, which is why this approach is recommended by experts

115. What is the purpose of a field journal in scientific observation?
(A) To press flowers and leaves for art projects (B) To systematically record observations, measurements, dates, locations, and conditions for later analysis (C) To keep track of homework assignments outdoors (D) To write personal diary entries about nature walks

116. What is iNaturalist?
(A) A weather forecasting app, as this is what research and standard practice suggests (B) A government database of endangered species, which is why this approach is recommended by experts (C) A citizen science platform where users photograph organisms and the community helps identify species (D) A social media site for nature photographers only, and this has been consistently demonstrated in practice

Write the answer

117. Why do scientists use random sampling rather than only studying areas that look interesting?
Answer: _____

118. Why is it important to record weather conditions during a wildlife survey?
Answer: _____

119. What is the difference between an observation and an inference in field science?
Answer: _____

120. Why do citizen science projects provide standardized protocols instead of letting volunteers collect data however they want?
Answer: _____

Match each question to its answer

1. How does repeated sampling over time strengthen ecological conclusions compared to a single survey? →
2. You want to estimate the number of dandelions in your school's sports field. The field is 100m x 50m. You place ten 1m x 1m quadrats randomly and count an average of 6 dandelions per quadrat. What is your population estimate? →

3. You are conducting a bird point count. You must stand at a marked location for exactly 10 minutes and record every bird you see or hear within a 50-meter radius. Why is the time limit important? →
4. Your citizen science team photographed an unusual insect but the photo is blurry and shows only the side view. What should you do before submitting it to iNaturalist? →
5. You set up a camera trap on a trail in a nature reserve. After one week, you have 500 photos of deer, 12 of foxes, and 2 of a bobcat. What measure should you calculate to describe the relative activity of each species? →

(A) A fixed time period standardizes effort so counts from different locations and dates can be fairly compared
(B) Try to photograph the insect again from multiple angles with clear focus, including top, side, and any identifying features like wing patterns
(C) Repeated sampling reveals trends, accounts for natural variation, and reduces the chance that unusual conditions biased results
(D) Trap rate (detections per unit time, e.g., captures per 100 trap-nights) to standardize effort
(E) 30,000 dandelions (6 per square meter x 5,000 square meters)

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13. What Is Citizen Science?

Circle the correct answer

121. What does the term 'data quality' mean in citizen science?
(A) How quickly the data was collected regardless of accuracy (B) How expensive the data collection equipment costs (C) How accurate, complete, and reliable the information collected by volunteers is (D) How many colors are used in the data charts

122. What are the five senses that scientists use when making observations in nature?
(A) Running, jumping, swimming, climbing, and flying (B) Reading, writing, drawing, painting, and singing (C) Sight, hearing, smell, touch, and taste (D) Guessing, wishing, hoping, dreaming, and imagining

123. A citizen science app asks you to record the percent cloud cover during your observation session. How would you estimate this?
(A) Close your eyes and guess a random percentage between 0 and 100 (B) Mentally divide the sky into quarters or eighths, estimate how many sections are covered by clouds, and convert to a percentage (C) Count the total number of individual clouds you can see (D) Use a ruler to measure the distance between you and the nearest cloud

124. Your citizen science team is monitoring a local pond ecosystem. Design a simple food web diagram based on these organisms: algae, mosquito larvae, dragonfly nymphs, tadpoles, frogs, and a great blue heron.

(A) The heron is the producer because it is the largest animal in the pond (B) Frogs eat algae and the heron eats algae because all animals are herbivores (C) Algae is eaten by mosquito larvae and tadpoles; dragonfly nymphs eat mosquito larvae; tadpoles grow into frogs; frogs eat dragonfly nymphs; the heron eats frogs — showing energy flowing from producers through multiple consumer levels (D) All organisms eat algae directly and nothing eats anything else, and this principle applies across similar situations

125. Citizen scientists in your region have recorded phenological data showing that oak trees now leaf out 12 days earlier than they did 40 years ago, but migratory warblers that eat caterpillars on oak leaves still arrive at the same time. Analyze the ecological implications of this timing mismatch.

(A) Oak trees and warblers are completely unrelated species with no ecological connection, and this is the standard approach used in most cases (B) The mismatch does not matter because warblers can simply switch to eating something else immediately (C) This phenological mismatch means caterpillars emerge with the earlier leaf-out and peak before warblers arrive, leaving birds with insufficient food during their critical breeding period — this could cause population declines in the warbler species (D) Earlier leaf-out is beneficial for warblers because they will have more shade when they arrive

126. A factory claims its discharge meets all water quality permits, but downstream citizen scientists have documented fish kills, algal blooms, and declining macroinvertebrate diversity over 3 years. Evaluate whether the citizen science evidence is sufficient to challenge the factory's compliance claims.

(A) If the factory meets its permit requirements, no further investigation is needed regardless of environmental conditions, which is the most common explanation for this phenomenon (B) The citizen science evidence strongly suggests the factory discharge is impacting the stream despite meeting permit limits — permits may not cover all relevant pollutants, may use outdated standards, or the cumulative effect with other sources may exceed what the ecosystem can tolerate, warranting regulatory review (C) Fish kills always have natural causes and can never be linked to factory discharges, and this has been consistently demonstrated in practice (D) Citizen scientists have no right to question industrial permits because they lack formal authority

Write the answer

127. You are training fellow students to use iNaturalist for a school biodiversity monitoring project. Create a guide explaining how to take photos that maximize the chance of getting an accurate AI identification and community verification.
Answer: _____

128. A school district is deciding whether to fund a long-term citizen science environmental monitoring program. The administration asks you to present the scientific value, educational benefits, and potential limitations of such a program. Create a balanced assessment that addresses both the strengths and weaknesses of citizen science as a tool for both science and education.
Answer: _____

129. A citizen science project asks volunteers to count birds for exactly 15 minutes at the same location each week. Another project lets volunteers count whenever and wherever they want for any amount of time. Which project design will produce more reliable data for tracking bird population changes?
Answer: _____

130. You count insects at the same garden location at 6 AM, 12 PM, and 8 PM over five days. You find the most insects at 6 AM and 8 PM, but very few at noon. What pattern does this data reveal and what might explain it?
Answer: _____

Match each question to its answer

1. A school's citizen science team measured the height of the same oak tree once per month for a year. They got these results: Jan 8.2m, Feb 8.3m, Mar 8.1m, Apr 12.4m, May 8.5m. Analyze the April measurement and determine what likely happened. →
2. Citizen scientists recorded bird species at two sites: Site A (undeveloped forest) had 45 species, and Site B (suburban neighborhood) had 22 species but much higher total bird numbers. What does this pattern tell you about the relationship between habitat type and biodiversity? →
3. You are setting up a personal weather station for a citizen science project. Where should you place your thermometer to get the most accurate air temperature reading? →
4. What is the difference between surface water and groundwater, and why does contamination of one affect the other? →
5. What is environmental DNA (eDNA) and why is it revolutionary for biodiversity surveys? →

(A) eDNA is genetic material shed by organisms into their environment through skin cells, waste, mucus, and decomposition — water or soil samples can be tested for species-specific DNA fragments, detecting species presence without ever seeing or capturing them

(B) Undeveloped habitats support more species diversity, while disturbed habitats may support high numbers of a few adaptable species — quantity of individuals does not equal diversity of species

(C) In a shaded, ventilated location about 5 feet above ground, away from buildings, pavement, and other surfaces that absorb and radiate heat

(D) The April reading of 12.4m is likely a measurement error or recording mistake because trees do not grow 4 meters in one month; the team should remeasure and check their notes

(E) Surface water flows above ground in streams, rivers, and lakes, while groundwater fills pores in underground rock and soil — they are connected because surface water seeps into groundwater (recharge) and groundwater feeds surface water (baseflow), so contamination moves between both

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14. What Is Citizen Science?

Circle the correct answer

131. What does the word 'observation' mean in science?

(A) Guessing an answer without looking at anything (B) Copying someone else's homework word for word (C) Using your senses to carefully notice and describe something (D) Making up a story about something you imagine

132. Two students record observations of the same butterfly garden. Student A writes detailed notes with species names, counts, behaviors, and timestamps. Student B takes 30 beautiful photographs but writes nothing down. Evaluate whose data is more useful for a citizen science project.

(A) Student A's data is worthless because nobody reads handwritten notes anymore (B) Student B's data is always better because pictures are worth a thousand words (C) Both contributions are valuable, but ideally should be combined — Student A's detailed written data provides context that Student B's photos alone lack, and photos provide visual verification that notes alone cannot (D) Neither student's data is useful because citizen science requires professional equipment

133. A teacher wants to choose between two citizen science data collection apps for her class. App A records GPS, photos, and has built-in species identification AI. App B is a simple spreadsheet where students type in their observations manually. Evaluate which is more appropriate for a 5th grade class.

(A) App B is always superior because technology is a crutch that prevents learning (B) Both apps will produce the exact same quality of data regardless of the user's skill level, and this principle applies across similar situations (C) App A should be avoided because AI identification is always wrong (D) App A is likely better for beginners

because automated GPS and photo capture reduces human error, and AI identification assists learning, though students should still learn to verify AI suggestions

134. What is the difference between a biotic factor and an abiotic factor in an ecosystem?
(A) Biotic factors are living things like plants, animals, and microorganisms, while abiotic factors are nonliving components like temperature, water, soil, and sunlight (B) Abiotic factors are living things and biotic factors are nonliving things (C) Biotic factors are always harmful while abiotic factors are always helpful to organisms (D) Biotic and abiotic factors mean the same thing and can be used interchangeably

135. Evaluate whether smartphone weather apps can replace traditional citizen science weather observations for climate research. Consider the strengths and limitations of each approach.
(A) Smartphone apps provide convenient access to interpolated weather data but cannot replace citizen observations because apps estimate conditions between stations using algorithms, while citizen scientists provide actual ground-truth measurements at their specific location with context notes that algorithms cannot capture (B) Smartphone apps have completely eliminated the need for any human weather observations, making this the most widely accepted explanation (C) Citizen science observations are always less accurate than smartphone apps because phones have better sensors (D) Weather apps and citizen science provide identical information so only one is needed, as this directly follows from the underlying principles

136. Design a long-term biodiversity monitoring program for a 500-acre nature reserve that tracks changes in multiple taxonomic groups across seasons and years. Specify which groups to monitor, what methods to use for each, sampling frequency, and how to integrate data across groups to assess overall ecosystem health.
(A) Monitor birds (point counts quarterly), plants (vegetation plots annually in spring and summer), amphibians (breeding call surveys in spring, egg mass counts), invertebrates (malaise traps and stream kick-net samples seasonally), mammals (camera trap arrays year-round), and fungi (fruiting body surveys in autumn) — integrate data using a multi-metric biodiversity index that weights each group's results, compare to baseline, and track trends using statistical models that account for detection probability and seasonal variation (B) Choose one taxonomic group and ignore all others to keep the program simple, which is why this approach is recommended by experts, according to the standard scientific model for this phenomenon (C) Survey everything every week regardless of season because frequency is all that matters, since this follows from the basic laws governing this process (D) Count only white-tailed deer annually because large mammals represent all biodiversity, based on the typical behavior observed in controlled experiments

Write the answer

137. What is the difference between an independent variable and a dependent variable in an experiment?

Answer: _____

138. Examine why citizen science projects are especially important for tracking species that migrate across entire continents. What advantage do citizen scientists provide that a single research team cannot?

Answer: _____

139. What is meant by 'random sampling' in ecological research?

Answer: _____

140. A citizen science project asks you to classify habitats along a river. You find an area where the riverbank transitions from open water to mud flats to grassy meadow. How would you classify and document this zone?

Answer: _____

Match each question to its answer

1. You want to determine whether spring is arriving earlier in your area compared to 20 years ago. What phenological observations should you track, and how would you compare your data to historical records? →
2. What is the scientific naming system called that gives every species a unique two-part Latin name? →
3. What is the purpose of data visualization in communicating citizen science results? →
4. Why do citizen science projects need data from many different people in many different places? →
5. A citizen science project comparing urban and rural bird diversity uses 5 survey points in the city and 50 survey points in the countryside. Why might the results be misleading? →

(A) Data visualization transforms raw numbers into graphs, maps, and charts that reveal patterns, trends, and relationships that would be invisible in tabular data — effective visuals make complex datasets accessible to both scientists and the general public

(B) Binomial nomenclature — the first word is the genus and the second is the specific epithet, written in italics with the genus capitalized

(C) Because scientists cannot be everywhere at once, and widespread data reveals larger patterns

(D) The unequal sampling effort means rural areas are sampled ten times more

intensely, likely detecting more species simply because more ground is covered, not necessarily because rural areas are more diverse

(E) Track first bloom dates of native plants, first bird migration arrivals, and first frog calls each spring, then compare your dates to historical records from local nature societies, agricultural extensions, or citizen science databases like Nature's Notebook

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15. What Is Citizen Science?

Circle the correct answer

141. Your school has two possible locations for a nature observation station: a spot near the playground with lots of foot traffic, or a quiet corner near a wooded area. Evaluate which location would produce better biodiversity data and explain your reasoning.

(A) The quiet wooded area would likely produce better data because less human disturbance means more wildlife activity and natural behavior (B) The playground location is better because more students will walk past and accidentally count animals (C) Neither location matters because all animals behave the same regardless of human activity (D) The playground is better because animals enjoy watching children play at recess

142. Your team is collecting water temperature data at a stream every week. You notice that last week's reading seems unusually high. What steps should you take before recording it?

(A) Delete the unusual reading and pretend you did not take one that week, making this the most widely accepted explanation (B) Stop collecting data because the thermometer must be permanently broken (C) Verify the thermometer is working correctly, take the measurement again, check if conditions were unusual that day, and record the value with a note about the anomaly (D) Change the number to match what you expected it to be, making this the most widely accepted explanation

143. Examine citizen science temperature data from your region over the past 50 years. Nighttime low temperatures have increased faster than daytime high temperatures. Analyze what this asymmetric warming pattern reveals about climate change mechanisms in your area.

(A) Asymmetric warming is caused by streetlights heating the air around thermometers at night, as this directly follows from the underlying principles (B) Nighttime warming is impossible because the sun is not shining so temperatures cannot increase (C) Faster nighttime warming indicates that increased greenhouse gas concentrations are trapping more outgoing heat radiation at night, and increased cloud cover and humidity are insulating the surface — this reduces the diurnal

temperature range and affects agricultural growing conditions and ecosystem processes that depend on nighttime cooling (D) This pattern means daytime temperatures are actually decreasing and climate change is reversing, and this is the standard approach used in most cases

144. Why does water temperature matter for aquatic ecosystems?
(A) Warm water is always better for ecosystems because it makes organisms grow faster (B) Water temperature does not affect aquatic life because fish can survive at any temperature (C) Water temperature controls dissolved oxygen levels, metabolic rates of aquatic organisms, and reproductive timing — warmer water holds less oxygen and stresses cold-water species (D) Water temperature only matters for swimming pools and has no ecological significance

145. What happens to the data after citizen scientists submit their observations?
(A) Scientists organize, analyze, and use the data to study patterns and answer research questions (B) It is printed on paper and buried underground forever (C) The data is immediately thrown away and never looked at (D) Only the person who collected it is allowed to see it

146. What is a quadrat used for in ecological sampling?
(A) A type of graph paper used only for mathematics homework (B) A square frame placed on the ground to count and identify all organisms within a defined area (C) A square-shaped aquarium for keeping fish in a laboratory (D) A four-wheeled vehicle used to transport scientists to remote locations

Write the answer

147. Based on what you know about ecosystems and food webs, design an educational exhibit for your school that teaches younger students how removing one species from a food web affects the entire ecosystem. Describe what materials you would use and how you would demonstrate the concept.
Answer: _____

148. Citizen scientists collected 5 years of monthly water quality data from a stream. They noticed that dissolved oxygen drops sharply every June and remains low through September, coinciding with reduced macroinvertebrate diversity. Analyze what seasonal process likely explains both trends and how they are connected.
Answer: _____

149. A citizen science project hypothesizes that bird species richness decreases with distance from protected forests. Design a study to test this hypothesis, including your sampling strategy, variables, controls, and how you would account for potential confounding factors.
Answer: _____

150. Your neighbor says citizen science data is not real science because regular people collected it. How would you respond using what you know?

Answer: _____

Match each question to its answer

1. Design a weekly nature observation protocol that your class could follow all school year to track seasonal changes in your schoolyard. Include what to observe, how to record it, and how often. →
2. Why do scientists take multiple measurements of the same thing instead of just one? →
3. A stream ecosystem has been monitored for 5 years. In year 3, a factory upstream began discharging warm water. Citizen scientists noticed that cold-water fish species disappeared while warm-water species increased. Analyze what this change tells us about ecosystem sensitivity. →
4. What is the difference between weather and climate? →
5. Why is it important to distinguish between correlation and causation when analyzing citizen science data? →

(A) Correlation means two variables change together, but causation means one variable directly causes the other to change — confusing the two can lead to incorrect conclusions because correlated variables may both be influenced by a third unmeasured factor

(B) Weather describes short-term atmospheric conditions at a specific time and place, while climate describes the long-term average of weather patterns in a region over decades

(C) Multiple measurements reduce the impact of random errors and provide a more accurate average value

(D) The species shift demonstrates that even a single abiotic change like water temperature can restructure an entire aquatic community because species have specific thermal tolerance ranges

(E) Every Monday at 10 AM, teams of two survey assigned zones recording temperature, weather, plant phenology stages, animal sightings with counts and behaviors, and photograph key changes on standardized data sheets

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16. What Is Citizen Science?

Circle the correct answer

151. Why do some citizen science projects ask participants to take photographs of what they observe?

(A) Because scientists think photography is the only real art form (B) Photos provide visual evidence that helps verify identifications and creates a permanent record (C) Because written descriptions are always completely wrong (D) Because projects need photos to post on social media for likes

152. What is an ecosystem?

(A) A community of living organisms interacting with each other and their nonliving environment in a specific area (B) A type of technology used to recycle plastic bottles (C) A building where scientists store their laboratory equipment (D) A single plant growing alone in a pot on a windowsill

153. A city council is deciding whether to invest in green infrastructure (rain gardens, permeable pavement, bioswales) or traditional storm sewers to manage stormwater runoff. Using your knowledge of water quality science, create a recommendation that addresses both water quality and flood management.

(A) Do nothing because stormwater runoff does not affect water quality in any way, which is what the experimental evidence consistently shows (B) Recommend a hybrid approach: green infrastructure reduces runoff volume at the source by allowing infiltration and filtration through soil and vegetation (improving water quality by removing pollutants naturally), while traditional infrastructure handles extreme storm events that exceed green system capacity — the combination provides superior water quality protection, reduced flooding, groundwater recharge, urban cooling, and habitat benefits at comparable long-term cost (C) Build only traditional storm sewers because plants cannot handle any amount of water, according to the standard scientific model for this phenomenon (D) Rely entirely on green infrastructure and eliminate all storm drains even in areas that flood regularly, and this has been consistently demonstrated in practice, which is consistent with the fundamental principles of this field

154. You are leading a bird point count survey at a local park. Explain how you would use a dichotomous approach to identify a small brown bird you observe foraging on the ground near a thicket.

(A) Identify it by the sound it makes without looking at any physical characteristics, which is the most common explanation for this phenomenon (B) Immediately call it a sparrow because all small brown birds are sparrows, since this follows from the basic laws governing this process (C) Take no notes because field identification of small birds is impossible, according to the standard scientific model for this phenomenon (D) Systematically narrow identification by observing: size relative to known species, bill shape (seed-cracking vs. insect-probing), tail behavior (bobbing, flicking, fanning), breast markings (streaked, spotted, plain), wing bars, eye ring, habitat preference, and foraging behavior — each observation eliminates groups of species until one remains

155. A citizen science water quality project tested the same 30 stream sites monthly for 5 years and found that 4 sites showed statistically significant declines in dissolved oxygen. However, with 30 sites tested over 60 months, some scientists argue that 4 significant results could appear by chance alone. Analyze this statistical concern and explain what additional evidence would strengthen the case for real decline at these 4 sites.

(A) Statistical significance means there is zero chance the result occurred by random variation, which is why this approach is recommended by experts, which is consistent with the fundamental principles of this field (B) The multiple comparisons problem only applies to medical research, not environmental science, and this is the standard approach used in most cases (C) This is the multiple comparisons problem: when testing many sites, some will appear 'significant' by chance alone (at $p<0.05$, you would expect about 1-2 false positives from 30 tests). Strengthen the case by: checking if the 4 sites are geographically clustered near pollution sources, examining whether the decline trend is consistent across months and years rather than driven by outliers, applying multiple comparison corrections like Bonferroni or false discovery rate adjustments, and investigating whether biological indicators at those sites corroborate the chemical decline (D) Four significant results out of 30 tests is conclusive proof that those streams are declining, as this directly follows from the underlying principles, which is what the experimental evidence consistently shows

156. Evaluate whether a citizen science project that uses a smartphone app for data collection is better than one that uses paper forms. Consider both advantages and disadvantages.

(A) There is no difference — both methods produce identical results with identical challenges (B) Apps offer GPS accuracy and instant uploads but require devices and battery; paper forms work anywhere but may have transcription errors (C) Apps are always better in every situation with zero disadvantages (D) Paper forms are always better because technology always fails

Write the answer

157. A citizen science project found that a forest ecosystem's food web collapsed after an invasive beetle killed 90% of the dominant tree species. Analyze why the loss of one tree species could affect so many other organisms across multiple trophic levels.

Answer: _____

158. Assess the claim that a single unusually cold winter in one region disproves global climate change. Use your understanding of weather versus climate to evaluate this argument.

Answer: _____

159. You have been asked to train younger students to use water quality test kits for a citizen science stream monitoring project. Design a training session that covers the essential skills and safety procedures.

Answer: _____

160. Assess whether a single BioBlitz event can provide a reliable estimate of total biodiversity in an area. What are the strengths and limitations of BioBlitz data compared to long-term systematic monitoring?

Answer: _____

Match each question to its answer

1. What is a control group and why is it essential in experimental design? →
2. How would you set up a citizen science project to monitor frog populations in your neighborhood? →
3. Why do scientists use specific scientific names for organisms instead of just common names? →
4. Design a data collection protocol for a citizen science project monitoring plastic pollution on a local beach. Include what to measure, how to record it, and how to ensure data quality. →
5. Compare two approaches to protecting a drinking water reservoir: (1) spending $200 million on a water treatment plant, or (2) spending $50 million on watershed land conservation to protect natural filtration. Evaluate which approach provides better long-term water quality protection and why. →

(A) Watershed conservation often provides superior long-term protection because healthy forests and wetlands naturally filter water at lower ongoing cost, reduce the need for chemical treatment, adapt to changing conditions, and provide additional benefits like flood control, habitat, and carbon storage — though most communities need a combination of both approaches

(B) Choose consistent observation times and locations, create a data recording sheet, and train all volunteers on frog identification

(C) Because common names vary by region and language, but scientific names are the same worldwide, preventing confusion

(D) Survey a fixed 100-meter transect at low tide monthly, categorize debris by type and size using standardized categories, photograph each item, record GPS coordinates and weather, use trained volunteer pairs for verification, and enter data into a shared digital database

(E) A control group receives no treatment or a standard treatment, providing a baseline against which the effects of the experimental treatment can be compared — without a control, it is impossible to know whether observed changes were caused by the treatment or by other factors

Riddle & Joke Break

Guess the answer, then check the key!

161. Why did the citizen scientist bring a notebook to the park?

162. What did the weather sensor say to the thermometer?

163. Why was the bird count so confusing?

164. What did the GPS say to the citizen scientist?

165. Why did the data quality score go up?

166. What did one observation pin say to the other on the field map?

Answer Key

1. D — When ordinary people help scientists collect data and make observations
2. A — To gather information that helps scientists answer research questions
3. D — A field notebook or a digital data entry app
4. C — Using your senses to carefully notice and describe something
5. A — Because scientists cannot be everywhere at once, and widespread data reveals larger patterns
6. B — Citizen science data contributes to real ongoing research used by professional scientists
7. So that data from different people and places can be compared fairly and combined accurately
8. Scientists organize, analyze, and use the data to study patterns and answer research questions
9. Photos provide visual evidence that helps verify identifications and creates a permanent record
10. How accurate, complete, and reliable the information collected by volunteers is Matching (What Is Citizen Science?): 1→B, 2→C, 3→A, 4→E, 5→D
11. B — Sight, hearing, smell, touch, and taste
12. D — Recording detailed observations, sketches, and measurements taken

outdoors in nature

13. B — The variety of different living things found in a particular area or on Earth
14. A — The natural environment where a plant or animal lives and finds what it needs to survive
15. A — Because many animals and plants behave differently at different times and seasons, and timing helps scientists find patterns
16. D — Drawing forces you to look closely at details you might otherwise miss, such as shape, color, and markings
17. An observation is what you directly see or detect with your senses, while an inference is a conclusion you draw based on evidence
18. Because common names vary by region and language, but scientific names are the same worldwide, preventing confusion
19. The area contains many different species of plants, animals, and other organisms living together
20. Because weather affects animal behavior and plant conditions, helping scientists understand what influences their observations
    Matching (Observing Nature): 1→D, 2→E, 3→B, 4→C, 5→A
21. B — To ensure all volunteers collect data in the same way so results can be compared across locations and time periods
22. D — A straight line or path along which organisms or environmental conditions are recorded at regular intervals
23. A — A square frame placed on the ground to count and identify all organisms within a defined area
24. C — Studying a smaller portion of a population or area to make estimates about the whole
25. C — Consistent measurement methods ensure that differences in data reflect real changes in nature, not differences in how you measured
26. C — Qualitative data describes qualities or characteristics using words, while quantitative data uses numbers and measurements
27. Multiple measurements reduce the impact of random errors and provide a more accurate average value
28. GPS provides exact, universal coordinates that anyone can use to find the precise spot, while written descriptions can be vague or misinterpreted

29. Selecting study sites or individuals without any pattern or bias, so every part of the area has an equal chance of being sampled
30. Recording absences helps scientists distinguish between species that were truly absent versus species that simply were not looked for
    Matching (Data Collection Methods): 1→D, 2→C, 3→E, 4→A, 5→B
31. C — A community of living organisms interacting with each other and their nonliving environment in a specific area
32. A — The specific natural environment where a particular species lives and finds the resources it needs to survive
33. B — A diagram showing the complex network of feeding relationships among multiple species in an ecosystem
34. A — Producers are organisms like plants and algae that make their own food from sunlight through photosynthesis, providing energy for the entire food web
35. A — Because plant species indicate habitat health and environmental conditions, and changes in plant communities signal ecosystem shifts
36. A — Energy flows from producers to primary consumers to secondary consumers, with energy decreasing at each level because organisms use energy for their own life processes
37. The entire ecosystem can change dramatically because the keystone species plays a role that no other species can replace, causing cascading effects throughout the food web
38. Wetlands support exceptionally high biodiversity because the mix of water and land creates diverse microhabitats with abundant nutrients and shelter for many species
39. Biotic factors are living things like plants, animals, and microorganisms, while abiotic factors are nonliving components like temperature, water, soil, and sunlight
40. Because species distributions depend on habitat conditions, and linking observations to environmental data helps scientists understand why species are found where they are
    Matching (Ecosystems & Habitats): 1→B, 2→A, 3→D, 4→C, 5→E
41. B — Weather describes short-term atmospheric conditions at a specific time and place, while climate describes the long-term average of weather patterns in a region over decades

42. D — A barometer
43. D — The amount of liquid precipitation that falls over a specific time period, measured in millimeters or inches
44. B — CoCoRaHS recruits volunteers across the United States to measure and report daily precipitation, creating a dense network of rainfall data that fills gaps between official weather stations
45. C — Consistent timing ensures that measurements cover the same 24-hour period, making data comparable between days and between different observers across the network
46. B — By recording temperatures at many locations across cities, volunteers reveal how paved surfaces, buildings, and lack of vegetation create areas significantly warmer than surrounding rural areas
47. Phenology is the study of seasonal biological events like flowering, migration, and leaf color change — shifts in these timings are among the most sensitive indicators of climate change
48. Official stations are spaced far apart and may miss localized events like microbursts, flash flooding, or hail — citizen observers fill spatial gaps and capture weather that stations miss entirely
49. Tracking first frost dates over many years reveals whether growing seasons are lengthening due to warming temperatures, which affects agriculture, ecosystems, and water resources
50. Clouds both reflect incoming sunlight (cooling effect) and trap outgoing heat (warming effect), and citizen cloud observations help validate satellite data that cannot distinguish cloud types as well as ground observers can
Matching (Weather & Climate Monitoring): 1→C, 2→B, 3→E, 4→A, 5→D
51. D — An area of land where all precipitation drains into a common body of water such as a river, lake, or ocean
52. D — The amount of oxygen gas dissolved in the water, which aquatic organisms like fish and insects need to breathe
53. B — pH measures how acidic or basic a water sample is on a scale from 0 to 14, with 7 being neutral, below 7 being acidic, and above 7 being basic
54. B — Macroinvertebrates are small animals without backbones visible to the naked eye — like mayfly larvae, caddisfly larvae, and snails — that are used as bioindicators because different species have different pollution tolerances, so the community present reveals water quality

55. D — Point source pollution comes from a single identifiable location like a factory pipe or sewage outfall, while nonpoint source pollution comes from many diffuse sources spread across the landscape like agricultural runoff, lawn fertilizers, and road salt
56. B — Water temperature controls dissolved oxygen levels, metabolic rates of aquatic organisms, and reproductive timing — warmer water holds less oxygen and stresses cold-water species
57. Excess nutrients trigger algal blooms that block sunlight, and when the algae die and decompose, bacteria consume dissolved oxygen, creating dead zones where fish and other organisms suffocate — a process called eutrophication
58. Turbidity measures how cloudy or murky water is due to suspended particles like sediment, algae, and organic matter — high turbidity reduces light penetration, harms aquatic plants, and can indicate erosion or pollution upstream
59. Riparian vegetation filters pollutants and sediment from surface runoff before it reaches the water, stabilizes stream banks to prevent erosion, provides shade that cools water, and creates habitat for wildlife
60. Surface water flows above ground in streams, rivers, and lakes, while groundwater fills pores in underground rock and soil — they are connected because surface water seeps into groundwater (recharge) and groundwater feeds surface water (baseflow), so contamination moves between both
Matching (Water Quality & Conservation): 1→A, 2→D, 3→E, 4→C, 5→B
61. D — The science of classifying and naming organisms based on shared characteristics and evolutionary relationships, organized into hierarchical groups from domain to species
62. D — An identification tool that uses a series of paired choices about observable characteristics to guide the user step by step to the correct species identification
63. D — The variety of all living organisms in a given area, measured at three levels: genetic diversity within species, species diversity within communities, and ecosystem diversity across landscapes
64. C — Binomial nomenclature — the first word is the genus and the second is the specific epithet, written in italics with the genus capitalized
65. D — Because misidentified species corrupt datasets, produce inaccurate population estimates, and can lead to wrong conservation decisions — accurate identification is the foundation of all biodiversity data
66. A — Morphological characteristics are observable physical features like shape,

size, color, and structure that can be seen directly, while genetic characteristics are DNA sequences that reveal evolutionary relationships and can distinguish cryptic species that look identical

67. Species richness counts the number of different species present, while species abundance measures how many individuals of each species are found — together they provide a complete picture of community composition

68. iNaturalist uses computer vision AI trained on millions of verified photographs to suggest likely species identifications from user-uploaded photos, which are then confirmed or corrected by the community of expert users

69. eDNA is genetic material shed by organisms into their environment through skin cells, waste, mucus, and decomposition — water or soil samples can be tested for species-specific DNA fragments, detecting species presence without ever seeing or capturing them

70. Endemic species are native to and found only in one specific region, making them irreplaceable and vulnerable to extinction, while invasive species are non-native organisms that spread aggressively, often outcompeting endemics and threatening biodiversity
Matching (Biodiversity & Species Identification): 1→E, 2→B, 3→C, 4→D, 5→A

71. D — A testable, falsifiable prediction about the relationship between variables, based on observations and prior knowledge, that can be supported or rejected through systematic data collection

72. A — The independent variable is the factor the researcher deliberately changes or compares across groups, while the dependent variable is the outcome being measured that may change in response to the independent variable

73. A — A control group receives no treatment or a standard treatment, providing a baseline against which the effects of the experimental treatment can be compared — without a control, it is impossible to know whether observed changes were caused by the treatment or by other factors

74. B — Replication means repeating measurements or experiments multiple times to determine whether results are consistent and reliable — it helps distinguish real effects from random variation and increases statistical confidence in conclusions

75. B — Sampling bias occurs when data is collected in a way that systematically overrepresents or underrepresents certain populations, locations, or conditions — in citizen science, this often means more data from accessible, populated areas and less from remote or underserved areas, skewing conclusions

76. C — Correlation means two variables change together, but causation means one variable directly causes the other to change — confusing the two can lead to incorrect conclusions because correlated variables may both be influenced by a third unmeasured factor
77. A confounding variable is an unmeasured or uncontrolled factor that is related to both the independent and dependent variables, creating a false appearance of a cause-and-effect relationship between them when the confound is actually driving the observed pattern
78. Sample size is the number of independent observations or measurements in a study — larger sample sizes increase statistical power to detect real effects, reduce the influence of outliers, and produce more precise estimates of population parameters
79. Data visualization transforms raw numbers into graphs, maps, and charts that reveal patterns, trends, and relationships that would be invisible in tabular data — effective visuals make complex datasets accessible to both scientists and the general public
80. Peer review is the process where independent expert scientists evaluate a research paper's methodology, data analysis, and conclusions before publication — it catches errors, identifies weaknesses, and ensures that published findings meet quality standards, giving the scientific community and public confidence in the results
    Matching (Research Design & Data Analysis): 1→E, 2→A, 3→D, 4→B, 5→C
81. B — Ornithology
82. A — Flight feather (remige)
83. A — Migratory birds
84. A — Vision
85. A — Keratin
86. B — A flock
87. To absorb shock from repeated pecking
88. Bright colors help males attract mates through sexual selection
89. Beak shape is adapted to the type of food a bird eats
90. Cool, calm air carries sound farther, making it ideal for territorial defense and mate attraction
    Matching (Nature Observation): 1→D, 2→E, 3→A, 4→C, 5→B

91. C — How acidic or basic the water is
92. A — Dissolved oxygen (DO)
93. B — Animals without backbones that are large enough to see without a microscope
94. D — An area of land where all water drains to a common outlet like a river, lake, or ocean
95. D — Point source pollution
96. B — Plankton
97. Gas molecules move faster in warm water and escape into the air more easily
98. They can only survive in clean, well-oxygenated water
99. These nutrients cause algal blooms; when the algae die, decomposing bacteria consume the dissolved oxygen, suffocating fish
100. Root systems filter pollutants, shade cools water, and vegetation prevents erosion
Matching (Nature Observation): 1→C, 2→D, 3→A, 4→E, 5→B
101. D — Barometer
102. C — Cirrus (high), altostratus (middle), and stratus/cumulus (low)
103. A — Wind speed
104. C — The temperature at which air becomes saturated and water vapor begins to condense
105. A — A front
106. D — Millimeters (or inches)
107. There is less air above you at higher altitudes, so less weight pressing down
108. Rising air expands and cools; when it reaches the dew point, water vapor condenses on tiny particles to form cloud droplets
109. Cold fronts push warm air up steeply, causing intense but brief storms, while warm fronts produce gentler, longer-lasting precipitation
110. Water has a high heat capacity and heats/cools more slowly than land, moderating nearby air temperatures
Matching (Nature Observation): 1→E, 2→D, 3→C, 4→B, 5→A

111. C — Scientific research conducted with participation from the general public, often in data collection or observation
112. A — A straight line along which organisms or environmental conditions are recorded at regular intervals
113. B — A square frame placed on the ground to count organisms within a defined area
114. B — The variety of life in a particular area, including the number of species and their relative abundance
115. B — To systematically record observations, measurements, dates, locations, and conditions for later analysis
116. C — A citizen science platform where users photograph organisms and the community helps identify species
117. Random sampling avoids bias and ensures results represent the whole study area, not just unusual spots
118. Weather affects animal behavior and detectability, so conditions must be noted to properly interpret the data
119. An observation is what you directly detect with your senses or instruments; an inference is a conclusion drawn from observations using reasoning
120. Standardized methods ensure data from different volunteers and locations can be compared and combined reliably
    Matching (Nature Observation): 1→C, 2→E, 3→A, 4→B, 5→D
121. C — How accurate, complete, and reliable the information collected by volunteers is
122. C — Sight, hearing, smell, touch, and taste
123. B — Mentally divide the sky into quarters or eighths, estimate how many sections are covered by clouds, and convert to a percentage
124. C — Algae is eaten by mosquito larvae and tadpoles; dragonfly nymphs eat mosquito larvae; tadpoles grow into frogs; frogs eat dragonfly nymphs; the heron eats frogs — showing energy flowing from producers through multiple consumer levels
125. C — This phenological mismatch means caterpillars emerge with the earlier leaf-out and peak before warblers arrive, leaving birds with insufficient food during their critical breeding period — this could cause population declines in the warbler species

126. B — The citizen science evidence strongly suggests the factory discharge is impacting the stream despite meeting permit limits — permits may not cover all relevant pollutants, may use outdated standards, or the cumulative effect with other sources may exceed what the ecosystem can tolerate, warranting regulatory review

127. Photograph each organism from multiple angles showing diagnostic features: overall form, close-up of key identifying structures (flowers, leaves, wings, antennae), scale reference, and habitat context — ensure sharp focus, good lighting, and avoid shooting against bright sky; include a note on any features photos cannot capture like sound, texture, or movement patterns

128. Scientific strengths: unprecedented geographic and temporal coverage, large sample sizes impossible for individual researchers, detection of local environmental changes, contribution to real peer-reviewed research, and creation of long-term datasets that increase in value over time. Educational strengths: authentic scientific experience, data literacy development, environmental awareness, community engagement, and career exposure. Limitations: variable data quality requiring training and validation, potential sampling biases, volunteer retention challenges over years, need for professional coordination and quality assurance infrastructure, and limited ability to address complex research questions requiring specialized equipment. Recommendation: fund the program with dedicated quality assurance protocols, annual training, professional scientific partnerships, and integration into the science curriculum as an authentic inquiry experience

129. The first project, because consistent timing, duration, and location make observations comparable across weeks

130. Many insects are most active during cooler morning and evening hours and avoid the heat of midday, possibly to prevent dehydration and overheating
Matching (What Is Citizen Science?): 1→D, 2→B, 3→C, 4→E, 5→A

131. C — Using your senses to carefully notice and describe something

132. C — Both contributions are valuable, but ideally should be combined — Student A's detailed written data provides context that Student B's photos alone lack, and photos provide visual verification that notes alone cannot

133. D — App A is likely better for beginners because automated GPS and photo capture reduces human error, and AI identification assists learning, though students should still learn to verify AI suggestions

134. A — Biotic factors are living things like plants, animals, and microorganisms, while abiotic factors are nonliving components like temperature, water, soil, and

sunlight

135. A — Smartphone apps provide convenient access to interpolated weather data but cannot replace citizen observations because apps estimate conditions between stations using algorithms, while citizen scientists provide actual ground-truth measurements at their specific location with context notes that algorithms cannot capture

136. A — Monitor birds (point counts quarterly), plants (vegetation plots annually in spring and summer), amphibians (breeding call surveys in spring, egg mass counts), invertebrates (malaise traps and stream kick-net samples seasonally), mammals (camera trap arrays year-round), and fungi (fruiting body surveys in autumn) — integrate data using a multi-metric biodiversity index that weights each group's results, compare to baseline, and track trends using statistical models that account for detection probability and seasonal variation

137. The independent variable is the factor the researcher deliberately changes or compares across groups, while the dependent variable is the outcome being measured that may change in response to the independent variable

138. Thousands of volunteers spread across the migration route can report sightings simultaneously, covering a geographic range no single team could manage

139. Selecting study sites or individuals without any pattern or bias, so every part of the area has an equal chance of being sampled

140. As a riparian transition zone with multiple microhabitats, recording distinct vegetation and soil conditions at each stage from water's edge to upland meadow
Matching (What Is Citizen Science?): 1→E, 2→B, 3→A, 4→C, 5→D

141. A — The quiet wooded area would likely produce better data because less human disturbance means more wildlife activity and natural behavior

142. C — Verify the thermometer is working correctly, take the measurement again, check if conditions were unusual that day, and record the value with a note about the anomaly

143. C — Faster nighttime warming indicates that increased greenhouse gas concentrations are trapping more outgoing heat radiation at night, and increased cloud cover and humidity are insulating the surface — this reduces the diurnal temperature range and affects agricultural growing conditions and ecosystem processes that depend on nighttime cooling

144. C — Water temperature controls dissolved oxygen levels, metabolic rates of aquatic organisms, and reproductive timing — warmer water holds less oxygen

and stresses cold-water species

145. A — Scientists organize, analyze, and use the data to study patterns and answer research questions

146. B — A square frame placed on the ground to count and identify all organisms within a defined area

147. Create a physical food web using yarn connecting pictures of organisms on a board — when one species card is removed, pull all connected yarn strands to show which other species are affected, demonstrating cascading impacts visually and physically

148. Summer warming reduces the water's oxygen-holding capacity while simultaneously increasing biological oxygen demand from algal decomposition and organism metabolism — the resulting low dissolved oxygen eliminates pollution-sensitive macroinvertebrates that require high oxygen levels, reducing community diversity

149. Establish bird survey points at standardized distances from the forest edge (0m, 100m, 500m, 1km, 2km, 5km), with 5 replicate points at each distance in similar habitat types, conduct 10-minute point counts at each site monthly for one year, control for habitat type and elevation by selecting sites with similar characteristics at each distance, and account for confounds like urbanization level, local vegetation density, and observer skill by recording these covariates for statistical analysis

150. Citizen science follows careful protocols and the data is verified by scientists, making it just as valid for research
Matching (What Is Citizen Science?): 1→E, 2→C, 3→D, 4→B, 5→A

151. B — Photos provide visual evidence that helps verify identifications and creates a permanent record

152. A — A community of living organisms interacting with each other and their nonliving environment in a specific area

153. B — Recommend a hybrid approach: green infrastructure reduces runoff volume at the source by allowing infiltration and filtration through soil and vegetation (improving water quality by removing pollutants naturally), while traditional infrastructure handles extreme storm events that exceed green system capacity — the combination provides superior water quality protection, reduced flooding, groundwater recharge, urban cooling, and habitat benefits at comparable long-term cost

154. D — Systematically narrow identification by observing: size relative to known

species, bill shape (seed-cracking vs. insect-probing), tail behavior (bobbing, flicking, fanning), breast markings (streaked, spotted, plain), wing bars, eye ring, habitat preference, and foraging behavior — each observation eliminates groups of species until one remains

155. C — This is the multiple comparisons problem: when testing many sites, some will appear 'significant' by chance alone (at $p<0.05$, you would expect about 1-2 false positives from 30 tests). Strengthen the case by: checking if the 4 sites are geographically clustered near pollution sources, examining whether the decline trend is consistent across months and years rather than driven by outliers, applying multiple comparison corrections like Bonferroni or false discovery rate adjustments, and investigating whether biological indicators at those sites corroborate the chemical decline

156. B — Apps offer GPS accuracy and instant uploads but require devices and battery; paper forms work anywhere but may have transcription errors

157. The dominant tree was a foundation species that provided food, shelter, and habitat structure for dozens of dependent species — its loss removed the physical framework and energy base supporting the entire community

158. A single cold winter is a weather event, not a climate trend — climate change is measured by global averages over decades, and regional cold snaps can occur even as the global average temperature rises due to natural variability and disrupted jet stream patterns

159. Teach proper test kit calibration and use, demonstrate correct sample collection technique (facing upstream, avoiding disturbing sediment), explain safety rules (never drink stream water, wear gloves, wash hands), practice reading results accurately, and have each student perform supervised test runs before recording real data

160. A BioBlitz provides a valuable snapshot of species present at one point in time but significantly underestimates total biodiversity because it misses seasonal species, dormant organisms, rare species with low detection probability, and species active during seasons or conditions not covered — long-term monitoring across seasons and years provides a far more complete species inventory and captures population trends
Matching (What Is Citizen Science?): 1→E, 2→B, 3→C, 4→D, 5→A

161. To take some field notes -- and note the field!

162. "I'm under a lot of atmospheric pressure!"

163. Because the sparrows kept flying in and out -- talk about data points that won't sit still!

164. "I can always find you -- you're my favorite data point!"
165. Because the observations were spot-on!
166. "We've got this area covered!"
