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BT201 Quiz File

Chapter-wise Solved MCQs

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Lesson 1: 1 Ecological Genomics Introduction, Bioinformatics

1. What initiative changed how biology is practiced, establishing it as an informational science?

- A) The Linnaean taxonomic classification
- B) The Human Genome Project (HGP)
- C) The development of light microscopy
- D) The discovery of C4 photosynthetic pathways

2. Which three primary disciplines intersect to form Bioinformatics?

- A) Mathematical sciences, Computer science, and Life sciences
- B) Geology, Paleontology, and Biophysics
- C) Organic chemistry, Thermodynamics, and Botany
- D) Applied ecology, Sociology, and Cladistics

3. According to the NIH definition cited in the text, what is the core specialization of Bioinformatics?

- A) Developing fertilizers for C3 agricultural crops
- B) Synthesizing lipid bilayers in aqueous environments
- C) Developing hardware and software to store and analyze large volumes of biological data
- D) Classifying macroclimates based on altitude and ground color

4. What is highlighted as a key challenge in modern bioinformatics?

- A) Replacing all cellular DNA with synthetic RNA transcripts
- B) Bridging the gap between technical data production and its use for biological discovery
- C) Eliminating web-based databases in laboratory research
- D) Converting digital genomes into physical paper records

Answer Key

* **1. B** — The Human Genome Project (HGP) transformed biology into an informational science focused on digital genomes and environmental signals.

* **2. A** — Bioinformatics is defined as an intersecting discipline combining mathematical sciences, computer science, and life sciences.

* **3. C** — The NIH defines bioinformatics as specializing in hardware and software development for storing and analyzing life science datasets.

* **4. B** — A main challenge of bioinformatics is bridging technical data production with its application in biological discovery by scientists.

Lesson 2: 2 Gene discovery (Genome analysis)

1. In a fully sequenced genome, how are genes typically identified?

- A) By conducting Edman degradation on all cell proteins
- B) By scanning the sequence with gene-predicting computer programs and searching database similarities
- C) By tracking phenotypic variations across wild populations
- D) By isolating whole chromosomes through light microscopy

2. How can ecologically important genes be identified when no genomic database exists for a study organism?

- A) By using pre-genomic molecular approaches
- B) By performing random cDNA microarray hybridization without sequence data
- C) By applying shotgun assembly without computer software
- D) By analyzing morphological traits in fossil specimens

3. In the effort to isolate the metallothionein (mt) gene in the springtail (*Orchesella sancta*), which initial approach failed?

- A) PCR using primers derived from the known *Drosophila* mt sequence
- B) Mass spectrometry of RNA transcripts
- C) Microarray expression profiling with *Arabidopsis* probes
- D) De novo shotgun sequence assembly

4. Which technique has largely replaced the laborious Edman degradation method for sequencing proteins?

- A) Polymerase Chain Reaction (PCR)
- B) Mass spectrometry
- C) DNA microarray profiling
- D) Northern blotting

Answer Key

* **1. B** — In fully sequenced genomes, genes are discovered by scanning sequences with prediction programs and searching existing databases for similarities.

* **2. A** — Pre-genomic molecular approaches allow researchers to identify key genes in incompletely characterized genomes lacking databases.

* **3. A** — Attempts to amplify the springtail mt gene via PCR using *Drosophila*-based primers were unsuccessful.

* **4. B** — Mass spectrometry has mostly replaced Edman degradation for determining peptide sequences from proteolytic digests.

Lesson 3: 3 Genomics Revolution Invading Ecology

1. According to Lederberg and McCray (2001), what does the suffix "-ome" signify?

- A) A single isolated nucleotide base
- B) The collectivity of units
- C) A specific enzymatic catalyst
- D) An extinct taxonomic lineage

2. How does genomics primarily differ from traditional ecology in its research scope?

- A) Genomics studies a few genes in many species, whereas ecology studies all genes in one species
- B) Genomics aims to investigate many genes simultaneously, whereas ecology usually deals with only a few genes
- C) Genomics focuses on fossilized structures, whereas ecology focuses on digital data
- D) Genomics avoids using computational tools, whereas ecology relies exclusively on high-speed servers

3. Who conceptualized the internal interactions between genes within a genome as an "internal tangled bank"?

- A) Charles Darwin
- B) Gabriel Dover
- C) Willi Hennig
- D) Carolus Linnaeus

4. Which three major technological developments of the 1990s powered the genomics revolution?

- A) Microtechnology, computing, and communication
- B) Steam power, electricity, and telecommunication
- C) Radiocarbon dating, light microscopy, and chromatography
- D) Recombinant DNA, tissue culture, and selective breeding

Answer Key

* **1. B** — The suffix "-ome" denotes the collectivity of units, as seen in terms like coelome and biome.

* **2. B** — Genomics investigates many genes at once within a genome, whereas traditional ecology typically examines a few genes across different phenotypes.

* **3. B** — Gabriel Dover (1999) proposed the "internal tangled bank" concept to describe dynamic gene interactions within the genome.

* **4. A** — The genomics revolution was driven by 1990s advancements in microtechnology, computing, and communication.

Lesson 4: 4 Schematic platform for Bioinformatics

1. How is a master sequence reconstructed using the shotgun approach to sequence assembly?

- A) By physically binding proteins under an electron microscope
- B) By examining short sequences for overlaps without needing prior genomic knowledge
- C) By comparing anatomical features between living and extinct species
- D) By calculating photosynthetically active radiation in ecosystems

2. Which of the following is explicitly listed as one of the three layers of genome annotation?

- A) Non-coding RNAs
- B) Endosymbiotic organelle transfer
- C) Microclimate topographic mapping
- D) Predator satiation refuges

3. Which gene prediction method relies solely on analyzing the target genome sequence without alignment?

- A) Trans-alignment
- B) Cis-alignment
- C) *Ab initio* / *de novo* prediction
- D) Mass spectrometry peptide matching

4. Which computational models are noted in bioinformatics annotation platforms (Stein 2001)?

- A) Lotka-Volterra differential equations

- B) Hidden Markov Models (HMMs) and Support Vector Machines (SVMs)
- C) Shelford's Law of Tolerance algorithms
- D) Linnaean binomial nomenclature codes

Answer Key

- * **1. B** — Shotgun sequence assembly reconstructs master sequences from short overlapping fragments without requiring prior genomic information.
- * **2. A** — Genome annotation consists of three layers: transcriptional control sites, non-coding RNAs, and mRNAs.
- * **3. C** — *Ab initio* or *de novo* prediction algorithms predict gene structures using only the target genome sequence.
- * **4. B** — Bioinformatics platforms utilize models like Hidden Markov Models (HMMs), Support Vector Machines (SVMs), and dynamic programming for annotation.

Lesson 5: 5 Phylogenetics

1. Who developed phylogenetic systematics (cladistics) in 1950?

- A) Carolus Linnaeus
- B) Willi Hennig
- C) Gabriel Dover
- D) J. Craig Venter

2. What do all branch nodes represent in a species tree?

- A) Gene duplication events
- B) Speciation events
- C) Point mutations
- D) Selective sweeps

3. Unlike a species tree, what can nodes in a gene tree represent in addition to speciation?

- A) Chromosomal inversion
- B) Gene duplication events
- C) Microclimate variation
- D) Extinction of outgroups

4. Which of the following is listed as a major reason for utilizing phylogenetics?

- A) Predicting gene function via phylogenetic footprinting
- B) Eliminating sewage in municipal aquifers
- C) Quantifying photosynthetic photon flux density
- D) Isolating proteins using Edman degradation

Answer Key

- * **1. B** — German entomologist Willi Hennig developed phylogenetic systematics (cladistics) in 1950.
- * **2. B** — In a species tree, every node strictly indicates a speciation event.
- * **3. B** — Nodes in a gene tree can represent either speciation or gene duplication events.
- * **4. A** — Major applications of phylogenetics include understanding species lineage, evolutionary function, sequence alignment, and predicting gene function through footprinting.

Lesson 6: 6 Yeast, fly, worm, and weed Part 2

1. In what year was the international Human Genome Project (HGP) launched by the US National Institutes of Health and Department of Energy?

- A) 1980
- B) 1990
- C) 1998
- D) 2005

2. Which private enterprise embarked on a human genome sequencing project that competed with and overtook the public Human Genome Project?

- A) Celera Genomics
- B) Genentech
- C) Venter Institute
- D) Illumina

3. Why do bacteria dominate the published list of complete genomes?

- A) They are the only organisms with eukaryotic cell structures
- B) The small size of their genomes makes them well-suited for whole-genome sequencing
- C) They do not contain any DNA sequences
- D) They are immune to all laboratory mutations

4. Which green alga species is listed among published plant genomes in the text?

- A) *Populus trichocarpa*
- B) *Chlamydomonas reinhardtii*
- C) *Oryza sativa*
- D) *Arabidopsis thaliana*

Answer Key

* **1. B** — The international Human Genome Project was launched in 1990 with an initial planned completion date of 2005.

* **2. A** — Celera Genomics was the private enterprise that used a different approach and overtook the public Human Genome Project.

* **3. B** — Bacteria dominate published genome lists because their small genome sizes make them well-suited for whole-genome sequencing.

* **4. B** — *Chlamydomonas reinhardtii* is specifically listed as a green alga among published eukaryotic genomes.

Lesson 7: 7 Yeast, fly, worm, and weed Part 3

1. Why was the sea squirt (*Ciona intestinalis*) selected as a genomic model organism?

- A) It is an agricultural crop species used for oil spill cleanups
- B) It belongs to the tunicates (invertebrate chordates) sitting at a crucial evolutionary position
- C) It has the largest eukaryotic genome ever discovered
- D) It carries out C4 photosynthesis

2. According to Nardi et al. (2003), what revised evolutionary development is suggested for the springtail (*Folsomia candida*)?

- A) It evolved directly from unicellular yeasts
- B) It developed the hexapod body plan before insects separated from crustaceans
- C) It is a member of the subphylum Vertebrata
- D) It lost its cell membrane during the Proterozoic era

3. Which nematode species is listed alongside *Caenorhabditis elegans* as having a complete published genome?

- A) *Caenorhabditis briggsae*
- B) *Bombyx mori*
- C) *Anopheles gambiae*
- D) *Drosophila melanogaster*

4. How does comparative genomics benefit the study of model genomes?

- A) By replacing all DNA sequencing with light microscopy
- B) By aiding in assigning gene functions and recognizing promoter sequences through comparison with reference organisms
- C) By proving that all organisms share identical phenotype expressions
- D) By eliminating the need for reference species at defined phylogenetic distances

Answer Key

* **1. B** — *Ciona intestinalis* was chosen because it belongs to tunicates, an invertebrate chordate group situated at a crucial position in the tree of life.

* **2. B** — *Folsomia candida* is suggested to have developed the hexapod body plan prior to the divergence of insects from crustaceans.

* **3. A** — *Caenorhabditis briggsae* is listed alongside *C. elegans* under the Nematoda group.

* **4. B** — Comparing a model genome with reference organisms at defined phylogenetic distances helps assign gene functions and identify promoter sequences.

Lesson 8: 8 Yeast, fly, worm, and weed Part 4

1. Why is the marine bacterium *Alcanivorax borkumensis* considered a valuable genomic model?

- A) It produces surfactants and participates in the biodegradation of hydrocarbons in oil spills
- B) It carries out C4 photosynthesis in deep ocean trenches
- C) It acts as an obligate parasite in snowshoe hares
- D) It is the primary producer of commercial soy sauce and cheese

2. Which nitrogen-fixing bacterium forms a symbiotic relationship with *Medicago truncatula* and serves as a model for nutrient cycling?

- A) *Escherichia coli*
- B) *Sinorhizobium meliloti*
- C) *Entamoeba histolytica*
- D) *Trypanosoma brucei*

3. What primary motivation is cited for sequencing the rice (*Oryza sativa*) genome?

- A) Its unique role in producing antibiotics
- B) Its huge importance as a staple food for the world population
- C) Its use as an animal model for cardiovascular diseases

D) Its ability to degrade petroleum products in soil

4. Which of the following dairy and food products is explicitly noted as being produced by important bacteria or fungi?

- A) Yoghurt
- B) Olive oil
- C) Cane sugar
- D) Corn starch

Answer Key

* **1. A** — *Alcanivorax borkumensis** produces surfactants and degrades hydrocarbons during oil spill cleanups.

* **2. B** — *Sinorhizobium meliloti** is a leguminous plant symbiont known for nitrogen fixation and modeling nutrient cycling.

* **3. B** — Sequencing rice was driven by its major significance as a global staple food crop.

* **4. A** — Bacteria and fungi are biotechnologically valuable for producing milk-derived foods like yoghurt and cheese.

Lesson 9: 9 Yeast, fly, worm, and weed Part 5

1. Which photosynthetic pathway do both model plants *Arabidopsis* and rice (*Oryza sativa*) utilize?

- A) C3 photosynthetic pathway
- B) C4 photosynthetic pathway
- C) Crassulacean Acid Metabolism (CAM)
- D) Anoxygenic bacterial photosynthesis

2. Why do genomicists suggest choosing new plant model organisms that utilize C4 or CAM pathways?

- A) To replace all bacterial model organisms in waste management
- B) To complement genomic knowledge of primary production across diverse plant physiological strategies
- C) Because C3 plants do not contain any messenger RNA transcripts
- D) Because CAM plants lack a cell wall

3. What strategy should new genomic model organisms embrace to capture broader biological insights?

- A) Focusing exclusively on domestic mammals
- B) Embracing diverse phylogenetic lineages with varying physiological and life-history strategies
- C) Restricting research strictly to extinct fossil groups
- D) Avoiding organisms with small genome sizes

4. What role is expected for whole-genome sequencing in future biodiversity research?

- A) It will become increasingly important across diverse phylogenetic lineages
- B) It will be entirely phased out in favor of morphological classification
- C) It will only apply to synthetic artificial organisms
- D) It will be restricted solely to viral pathogens

Answer Key

- * **1. A** — Both *Arabidopsis* and rice rely on the C3 photosynthetic pathway.
- * **2. B** — Selecting C4 and CAM plant models complements existing C3 data to better understand global primary production.
- * **3. B** — Future model selection must cover diverse phylogenetic lineages representing different life histories and physiologies.
- * **4. A** — Whole-genome sequencing is expected to expand and become far more important for studying biodiversity in the future.

Lesson 10: 10 -Omics speak Part 1

1. What field of study is defined as the analysis of all low molecular weight cellular constituents?

- A) Transcriptomics
- B) Proteomics
- C) Metabolomics
- D) Genomics

2. According to Zhou et al. (2004), which three main categories can be used to classify genomics?

- A) Approach, scientific discipline, and object of study
- B) Kingdom, phylum, and class
- C) Primary, secondary, and tertiary succession
- D) Ingroup, outgroup, and clade

3. What term refers to the study of all carbohydrates present within a cell?

- A) Vaccinomics
- B) Saccharomics
- C) Cardiogenomics
- D) Pharmacogenomics

4. Which three disciplines represent the most common extensions of genomics?

- A) Anatomy, Histology, and Cytology
- B) Transcriptomics, Proteomics, and Metabolomics
- C) Taxonomy, Cladistics, and Phylogenetics
- D) Ecology, Geology, and Meteorology

Answer Key

- * **1. C** — Metabolomics investigates low molecular weight cellular constituents and small metabolites.
- * **2. A** — Zhou et al. (2004) classified genomics by approach (structural/functional), scientific discipline, and object of study.
- * **3. B** — Saccharomics is described as the study of all carbohydrates in the cell.
- * **4. B** — Transcriptomics, proteomics, and metabolomics are highlighted as the three most common extensions of genomics.

Lesson 11: 11 -Omics speak Part 2

1. What is transcriptomics primarily defined as in functional genomics?

- A) The study of all low molecular weight cellular constituents
- B) The study of all transcripts present at any time in the cell
- C) The study of all carbohydrates in a cell
- D) The sequence assembly of whole eukaryotic chromosomes

2. Although the transcriptome encompasses all RNA types in principle, what is transcriptomics usually limited to in practice?

- A) Ribosomal RNA (rRNA)
- B) Transfer RNA (tRNA)
- C) Messenger RNA (mRNA)
- D) Small nuclear RNA (snRNA)

3. Why is transcriptomics classified as a branch of functional genomics?

- A) Because it investigates static DNA structures rather than cell functions
- B) Because it examines gene functions and expression rather than DNA sequence as such
- C) Because it eliminates the need for computer databases
- D) Because it isolates proteins using Edman degradation

4. What mechanism allows a single pre-mRNA to produce multiple different mRNAs, leading to more transcripts than protein-encoding genes?

- A) Polymerase Chain Reaction
- B) Alternative splicing
- C) Shotgun sequence assembly
- D) Trans-alignment

Answer Key

* **1. B** — Transcriptomics is defined as the study of all transcripts present in a cell at any given time.

* **2. C** — Although the transcriptome includes all RNA classes, transcriptomics usually focuses on mRNA, the template for translation into protein.

* **3. B** — Studying transcriptomes is part of functional genomics because it investigates gene function under specific conditions rather than static DNA sequences.

* **4. B** — Alternative splicing generates multiple different mRNA transcripts from the same pre-mRNA during the removal of introns.

Lesson 12: 12 -Omics speak Part 3**1. Which analytical technique is used in proteomics to determine protein amino acid sequences by analyzing proteolytic fragments?**

- A) Northern blotting
- B) Mass spectrometry
- C) DNA microarray profiling
- D) Polymerase Chain Reaction

2. Which protease is explicitly cited in the handout as an example tool for cleaving proteins into characteristic fragments?

- A) Trypsin

- B) RNA polymerase
- C) DNA ligase
- D) Reverse transcriptase

3. What is highlighted as a primary reason for the lack of correlation between mRNA and protein abundances?

- A) The absence of cell ribosomes
- B) Control mechanisms at ribosomes and post-translational modifications
- C) Equal decay rates of all transcripts
- D) The lack of functional enzymes in cytoplasm

4. According to the text, which three disciplines must be considered together to fully understand a living cell in a molecular biology context?

- A) Microclimates, Topography, and Soil composition
- B) Genome, Transcriptome, and Proteome
- C) C3 plants, C4 plants, and CAM plants
- D) Ingroup, Outgroup, and Clade

Answer Key

* **1. B** — Mass spectrometry determines protein sequences by matching proteolytic fragments against in silico genome digestions.

* **2. A** — Trypsin is specified as a protease used to cleave proteins into distinct peptide fragments for comparison.

* **3. B** — Discrepancies between mRNA and protein levels stem from ribosomal controls, variable degradation, and post-translational modifications.

* **4. B** — A complete molecular understanding of a cell requires evaluating the genome, transcriptome, and proteome together.

Lesson 13: 13 -Omics speak Part 4

1. How is metabolomics defined in the course handout?

- A) The study of all high molecular weight nucleic acids
- B) The study of all low molecular weight cellular constituents
- C) The classification of macroclimates across biomes
- D) The sequence alignment of ribosomal RNA genes

2. Why can no single analytical method measure all metabolites in a cell simultaneously?

- A) Because all metabolites share identical chemical structures
- B) Because metabolites possess greatly diverging chemical properties (e.g., hydrophilic vs. hydrophobic)
- C) Because cells destroy all metabolites during extraction
- D) Because metabolomics avoids using digital instrumentation

3. Which analytical technique is explicitly listed as a method used to measure specific categories of metabolites?

- A) Edman degradation
- B) Pyrolysis gas chromatography
- C) Shotgun sequence assembly

D) Cis-alignment

4. What is required to obtain a complete picture of a cell's metabolome?

- A) A single universal reagent
- B) A diversity of analytical approaches
- C) Light microscopy alone
- D) Eliminating computer models

Answer Key

* **1. B** — Metabolomics specifically focuses on analyzing low molecular weight cellular constituents and small metabolites.

* **2. B** — Diverging chemical properties like hydrophilicity, acidity, and reactivity prevent any single method from detecting all metabolites at once.

* **3. B** — Pyrolysis gas chromatography and infrared spectrometry are analytical techniques mentioned for measuring specific metabolite categories.

* **4. B** — Capturing the complete metabolome requires deploying multiple varied analytical approaches to handle chemical diversity.

Lesson 14: 14 Gene discovery Part 1

1. How are putative functions assigned to newly predicted genes in a fully sequenced genome?

- A) By observing behavioral changes in wild populations
- B) By searching for similarities in existing databases
- C) By measuring total photosynthetic radiation
- D) By performing manual Edman degradation on cell lysates

2. What common challenge is encountered when conducting gene discovery in ecological genomics?

- A) The total absence of DNA in non-model species
- B) No genomic database being available for the study organism
- C) Excessively high correlation between mRNA and protein levels
- D) Complete lack of computer software

3. In the attempt to isolate the metallothionein (mt) gene in the springtail (*Orchesella cincta*), which initial approach failed?

- A) PCR using primers based on the *Drosophila* mt sequence
- B) Mass spectrometry of proteolytic digests
- C) Microarray expression profiling
- D) Pyrolysis gas chromatography

4. Why did PCR primers derived from *Drosophila* fail to amplify the mt gene in *Orchesella cincta*?

- A) *Orchesella cincta* lacks a cell nucleus
- B) The DNA sequence had diverged too much between the species
- C) PCR cannot be performed on insect tissues
- D) The mt gene only exists in plants

Answer Key

* **1. B** — In fully sequenced genomes, predicted genes are assigned putative functions by matching similarities in existing databases.

* **2. B** — Ecological genomics often studies non-model organisms for which no pre-existing genomic database exists.

* **3. A** — Attempting to amplify the springtail mt gene using PCR primers derived from *Drosophila* was unsuccessful.

* **4. B** — Cross-species PCR amplification failed because sequence divergence between *Drosophila* and the springtail was too great.

Lesson 15: 15 Gene discovery Part 2

1. When starting gene discovery without a genomic database, what cellular component can serve as the starting point?

- A) The primary structure of a gene product (protein)
- B) Total atmospheric nitrogen concentration
- C) The fossilized shell of an extinct outgroup
- D) The lipid composition of the nuclear envelope

2. Which proteins are particularly suited as starting points for working backwards to gene characterization?

- A) Proteins that can be easily isolated by a marker or bioassay
- B) Proteins that lack any amino acid sequence
- C) Synthetic proteins produced without DNA templates
- D) Structural lipids found in cell membranes

3. What strategy is described for discovering genes when no reference genome is available?

- A) Working backwards from protein structure to gene characterization
- B) Replacing DNA sequencing with satellite remote sensing
- C) Estimating total species richness in marine ecosystems
- D) Eliminating the use of PCR in molecular biology

4. Why is working backwards from protein structure significant in ecological applications?

- A) It bypasses the laws of thermodynamics
- B) It may be the only way to begin genomic explorations in uncharacterized ecological species
- C) It proves that all proteins are identical across taxa
- D) It eliminates the need for computer data storage

Answer Key

* **1. A** — The primary structure of a protein product can serve as the initial entry point for gene discovery.

* **2. A** — Easily isolated proteins detected via specific markers or bioassays are ideal starting points.

* **3. A** — Researchers can work backwards from isolated protein structures to characterize the corresponding genes.

* **4. B** — Working backwards from protein structure is often the only feasible strategy to initiate genomic research in non-model ecological organisms.

Lesson 16: 16 Structure and function in communities

1. According to Lawton (1994), what fundamental question does ecological genomics help explore in communities?

- A) How do organisms synthesize lipid bilayers?
- B) What do species do in ecosystems?
- C) Why do all viruses lack cell membranes?
- D) How many chromosomes are in eukaryotic gametes?

2. Which group of organisms is described as occupying a key position at many crucial links of nutrient cycles?

- A) Microorganisms
- B) Large mammalian herbivores
- C) Avian frugivores
- D) Gymnosperm seed plants

3. How is community structure essentially defined in the text?

- A) The total biomass of non-living organic matter in soil
- B) The composition of a community, including the number of species and their relative numbers
- C) The rate of solar radiation absorption by atmospheric ozone
- D) The sequence alignment of mitochondrial transfer RNAs

4. Broadly interpreted, what else does community structure include in addition to species counts and relative numbers?

- A) Patterns of interaction between different species
- B) The rate of tectonic plate movement
- C) The chemical composition of basaltic rocks
- D) The molecular weight of ribosomal subunits

Answer Key

* **1. B** — Lawton (1994) posed the question "what do species do in ecosystems?", which ecological genomics helps investigate.

* **2. A** — Microorganisms are highlighted as occupying key positions in nutrient cycle links.

* **3. B** — Community structure refers to community composition, encompassing species numbers and relative abundances.

* **4. A** — Broadly defined, community structure includes the patterns of interaction among different species.

Lesson 17: 17 How do we measure community structure?

1. What two primary measures do ecologists use to describe the composition of a community?

- A) Biomass density and soil acidity
- B) Species richness and species diversity
- C) Primary production and mutation rate
- D) Gene flow and chromosomal inversion

2. How is species richness defined?

- A) The total number of individual organisms per unit area
- B) The number of different species in a particular community
- C) The ratio of autotrophs to heterotrophs

D) The percentage of extinct species in a fossil bed

3. Geographically, where are communities with the highest species richness typically found?

- A) Near the poles where temperatures are coldest
- B) Near the equator in tropical latitudes
- C) In deep sub-surface aquifers
- D) In high-altitude alpine tundras

4. Species diversity is a function of which two factors?

- A) Temperature variation and altitude
- B) Species richness and species evenness (relative abundances)
- C) Mutation frequency and genetic drift
- D) Soil moisture and wind velocity

Answer Key

* **1. B** — Species richness and species diversity are the two key measures used to describe community composition.

* **2. B** — Species richness is defined specifically as the total number of different species present in a community.

* **3. B** — Communities with the highest species richness occur in tropical regions near the equator.

* **4. B** — Species diversity combines species richness with species evenness (their relative abundances).

Lesson 18: 18 What factors shape community structure

1. How does environmental heterogeneity (patchiness) affect species richness in a community?

- A) It reduces species richness by destroying all microhabitats
- B) It allows for greater species richness by providing more distinct habitats
- C) It prevents seed germination across all plant lineages
- D) It eliminates interspecific competition entirely

2. According to the intermediate disturbance hypothesis, which level of disturbance fosters the highest species diversity?

- A) Extremely frequent disturbances
- B) Medium (intermediate) levels of disturbance
- C) Complete absence of any disturbance
- D) Unpredictable catastrophic extinctions

3. Why do island communities further away from a mainland tend to have fewer species than islands closer to the mainland?

- A) Distant islands lack solar radiation
- B) Arrival of a species from the mainland is a chance event that is less likely over greater distances
- C) Distant islands contain no soil or rock substrates
- D) Predators are twice as abundant on isolated islands

4. How can chance historical events shape community structure?

- A) By changing the laws of thermodynamics
- B) Whether a single seed takes root can determine which species becomes dominant

- C) By preventing any organism from reproducing
- D) By fixing all alleles in a population instantly

Answer Key

- * **1. B** — Greater environmental heterogeneity offers more distinct habitats, supporting higher species richness.
- * **2. B** — The intermediate disturbance hypothesis states that intermediate levels of disturbance support peak species diversity.
- * **3. B** — Species arrival from the mainland is less likely over longer distances due to lower immigration probability.
- * **4. B** — Chance events, such as whether an initial seed sprouts, can dictate which species establishes and dominates.
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Lesson 19: 19 Foundation and keystone species

1. What defines a foundation species in an ecological community?

- A) A species that has the lowest biomass in an ecosystem
- B) A species that plays a unique, essential role in creating and defining a community, often by modifying the environment
- C) An introduced pathogen that causes 100% mortality
- D) A unicellular prokaryote that lacks a cell wall

2. Which organism is explicitly identified in the handout as a foundation species forming kelp forests off the California coast?

- A) Red jungle fowl
- B) Kelp (brown algae)
- C) Asian carp
- D) Prickly pear cactus

3. How do keystone species differ from foundation species?

- A) Keystone species always have the highest total biomass
- B) Keystone species are more likely to be top predators and act in more diverse ways
- C) Keystone species are exclusively unicellular fungi
- D) Keystone species only exist in extreme polar environments

4. Why are coral reef corals classified as foundation species?

- A) They hunt top predators in deep pelagic zones
- B) Their exoskeletons form most of the reef structure, protecting other species from waves and ocean currents
- C) They carry out C4 photosynthesis during night hours
- D) They produce methane gas to alter water pH

Answer Key

- * **1. B** — Foundation species shape communities by creating structural habitats and modifying the physical environment.
- * **2. B** — Kelp (brown algae) serves as a foundation species that defines coastal California kelp forest communities.

* **3. B** — Keystone species exert disproportionate effects relative to biomass, often acting as top predators in diverse ways.

* **4. B** — Living and dead coral exoskeletons form the physical reef framework that shelters other marine organisms.

Lesson 20: 20 Invasive Species

1. What is an invasive species according to the text?

- A) Any native species that reproduces during spring months
- B) A species introduced outside its native range that has the potential to cause harm
- C) An extinct organism preserved in amber
- D) A domesticated crop grown exclusively in greenhouses

2. Why was the kudzu vine originally planted widely in the southern United States in the early 1900s?

- A) To produce commercial antibiotics
- B) To reduce soil erosion
- C) To eradicate malaria-carrying mosquitoes
- D) To serve as an artificial building material

3. For what purpose were Asian carp originally imported to the United States in the 1970s?

- A) To serve as livestock feed in alpine pastures
- B) To use their filter feeding abilities to rid ponds of excess plankton in fisheries and sewage treatment ponds
- C) To control wild rodent populations in forests
- D) To produce decorative pearls for export

4. What ecological impact can invasive species have on native species in a community?

- A) They increase native species diversity by 500%
- B) They may outcompete native species for resources or habitat, potentially leading to extinctions
- C) They convert all eukaryotic cells into prokaryotic cells
- D) They prevent solar radiation from reaching the biosphere

Answer Key

* **1. B** — Invasive species are non-native introductions that cause or threaten ecological or economic harm.

* **2. B** — Kudzu was distributed in the early 20th century primarily to control soil erosion.

* **3. B** — Asian carp were imported to clear excess plankton from fisheries and sewage treatment ponds via filter feeding.

* **4. B** — Invasive species disrupt communities by outcompeting native organisms for food and habitat.

Lesson 21: 21 Introduction to the Animal kingdom

1. What percentage of all known animal species do invertebrates represent?

- A) 5%
- B) 50%
- C) 75%
- D) 95%

2. Which group of organisms is explicitly cited as having an asymmetrical body plan?

- A) Jellyfish
- B) Sponges
- C) Sea anemones
- D) Starfish

3. Which of the following is a defining cellular characteristic of all animals?

- A) Multicellular, eukaryotic, and heterotrophic organisms without cell walls
- B) Unicellular prokaryotic organisms with peptidoglycan walls
- C) Autotrophic organisms possessing chloroplasts and chitinous walls
- D) Unicellular eukaryotes with silica shells

4. How is radial symmetry defined in the handout?

- A) A body plan that cannot be divided into equal halves
- B) A body plan divided into two equal halves when any line is drawn through its center
- C) A body plan divided into two equal halves by only one line drawn through its center
- D) A body plan possessing a head and tail region

Answer Key

- **1. D** — Invertebrates lack a backbone and constitute 95% of all animal species
- **2. B** — Sponges are the only animal group noted as lacking an organized body plan and being asymmetrical
- **3. A** — Animals are defined as multicellular, eukaryotic heterotrophs whose cells do not possess cell walls
- **4. B** — Radial symmetry allows an organism's body to be divided into equal halves along any plane passing through the central axis

Lesson 22: 22 Features of protists

1. What material forms the protective outer shells of diatoms?

- A) Chitin
- B) Calcium carbonate
- C) Silica
- D) Cellulose

2. Which major agricultural crisis in human history was caused by water molds?

- A) The Bengal Rice Blight
- B) The Irish Potato Famine
- C) The Great Dust Bowl
- D) The European Wheat Rust

3. What are the three primary functional categories used to classify protists?

- A) Protozoans, Algae, and Fungus-like protists
- B) Bacteria, Archaea, and Eukarya
- C) Ciliates, Flagellates, and Sporozoans
- D) Monera, Fungi, and Metazoa

4. Which form of brown algae is highlighted as a multicellular marine protist?

- A) Volvox

- B) Spirogyra
- C) Kelp
- D) Euglena

Answer Key

- **1. C** — Diatoms are unicellular photosynthetic protists encased within silica shells
- **2. B** — Water molds caused the Irish potato famine, which led to two million deaths and widespread emigration
- **3. A** — Protists are divided into three main groups: protozoans (animal-like), algae (plant-like), and fungus-like protists
- **4. C** — Kelp is specifically listed as a multicellular marine form of brown algae

Lesson 23: 23 Protozoa

1. What vector transmits *Trypanosoma*, the flagellated protozoan responsible for African Sleeping Sickness?

- A) Anopheles mosquito
- B) Tsetse fly
- C) Deer tick
- D) Sandfly

2. What is the primary function of the contractile vacuole in an *Amoeba*?

- A) Digesting engulfed food particles via enzymes
- B) Collecting excess intracellular water and expelling it from the cell
- C) Replicating chromosomes during binary fission
- D) Storing starch and paramylon granules

3. Which sexual process in *Paramecium* involves the exchange of genetic information to increase diversity?

- A) Binary fission
- B) Multiple fission
- C) Conjugation
- D) Budding

4. Which drug is specifically noted in the handout for treating malaria caused by *Plasmodium*?

- A) Penicillin
- B) Quinine
- C) Saxitoxin
- D) Trypsin

Answer Key

- **1. B** — *Trypanosoma* is a parasitic flagellated protozoan spread by the tsetse fly
- **2. B** — The contractile vacuole collects excess water from inside the cell and gets rid of it
- **3. C** — *Paramecium* undergoes conjugation as a sexual reproduction process to exchange genetic material

- **4. B** — Quinine is cited as the drug utilized to treat malaria caused by *Plasmodium*

Lesson 24: 24 Phylum Arthropoda

1. What percentage of all known animal species belongs to the Phylum Arthropoda?

- A) 25%
- B) 50%
- C) 75%
- D) 95%

2. What process must arthropods undergo in order to shed their heavy exoskeleton and grow?

- A) Tagmatization
- B) Conjugation
- C) Ecdysis (molting)
- D) Metamerism

3. How many pairs of antennae do crustaceans possess, distinguishing them from other arthropod subphyla?

- A) Zero pairs
- B) One pair
- C) Two pairs
- D) Three pairs

4. Which type of toxin is produced by the brown recluse spider (*Loxosceles reclusa*), causing severe tissue necrosis?

- A) Saxitoxin
- B) Neurotoxin
- C) Hemolytic necrotoxin
- D) Ciguatera

Answer Key

- **1. C** — Arthropods comprise 75% of all described animal species

- **2. C** — Arthropods must shed their rigid exoskeleton through ecdysis (molting) to permit body growth

- **3. C** — Crustaceans possess two pairs of antennae, unlike other arthropod subphyla

- **4. C** — The brown recluse spider (*Loxosceles reclusa*) injects a hemolytic necrotoxin that causes tissue necrosis

Lesson 25: 25 Phylum Annelida

1. What type of segmentation defines true segmented worms in Phylum Annelida?

- A) Tagmatization
- B) Metameric segmentation
- C) Pseudocoelous division
- D) Radial cleavage

2. Which respiratory pigment is present in the closed circulatory system of annelids to increase oxygen-carrying capacity?

- A) Hemocyanin
- B) Hemoglobin
- C) Chlorocruorin
- D) Myoglobin

3. In tube-dwelling worms of Family Siboglinidae, what organ is filled with chemosynthetic bacteria that play a crucial role in nutrition?

- A) Clitellum
- B) Trophosome
- C) Parapodium
- D) Opisthosoma

4. Which substance is excreted by the salivary glands of leeches (Subclass Hirudinea) to prevent host blood from coagulating?

- A) Hirudin
- B) Trypsin
- C) Saxitoxin
- D) Chitin

Answer Key

* **1. B** — Annelids are true segmented worms characterized by metameric body segmentation.

* **2. B** — Annelid blood flows in closed vessels and contains hemoglobin to increase oxygen-carrying ability.

* **3. B** — In Family Siboglinidae, gut tissue forms a trophosome organ packed with chemosynthetic bacteria.

* **4. A** — Leeches excrete hirudin from their salivary glands to inhibit blood coagulation while feeding.

Lesson 26: 26 Echinodermata

1. What type of body symmetry is characteristic of adult echinoderms?

- A) Bilateral symmetry
- B) Asymmetry
- C) 5-pointed radial symmetry
- D) Spherical symmetry

2. What material composes the internal skeleton (ossicles) of echinoderms?

- A) Silica
- B) Calcium carbonate
- C) Chitin
- D) Spongin

3. What is the primary function of the contraction and expansion of the ampullae in echinoderms?

- A) Pumping digestive enzymes
- B) Accomplishing movement of the tube feet
- C) Secreting a chitinous cuticle
- D) Generating bioluminescence

4. What is the name of the larval stage in sea star (Class Stelleroidea) reproduction?

- A) Trochophore
- B) Nauplius
- C) Bipinnaria
- D) Planula

Answer Key

- **1. C** — Adult echinoderms exhibit 5-pointed radial symmetry.
- **2. B** — Echinoderms possess an internal skeleton made of calcium carbonate ossicles manufactured by specialized cells.
- **3. B** — Contraction and expansion of the ampulla accomplishes movement of the tube foot.
- **4. C** — The free-swimming larval stage of sea stars is known as a bipinnaria.

Lesson 27: 27 chordates,

1. Which of the following is one of the five distinctive characteristics that define all chordates at some stage of their life cycle?

- A) Exoskeleton made of chitin
- B) Notochord
- C) Open circulatory system with a hemocoel
- D) 5-pointed radial symmetry

2. Why are chordates classified as deuterostomes?

- A) The mouth forms before the anus during embryonic development
- B) The anus forms before the mouth during embryonic development
- C) They lack a coelom during blastula stages
- D) They exhibit radial symmetry as adults

3. What are the names of the dorsal (top) and ventral (lower) parts of the shell in turtles and tortoises (Order Chelonia)?

- A) Cephalothorax and Abdomen
- B) Carapace and Plastron
- C) Trophosome and Opisthosoma
- D) Tagma and Metamere

4. Which order of reptiles is noted as being most closely related to dinosaurs?

- A) Order Chelonia
- B) Order Squamata
- C) Order Crocodilia
- D) Order Rhynchocephalia

Answer Key

- **1. B** — A notochord is one of the five core diagnostic features defining all chordates.
- **2. B** — Deuterostome development is characterized by the anus forming prior to the mouth during embryogenesis.
- **3. B** — Order Chelonia shells consist of a top dorsal carapace and a lower ventral plastron.
- **4. C** — Members of Order Crocodilia are the living reptiles most closely related to dinosaurs.

Lesson 28: 28 Soft and permeable or hard, impermeable

1. What process must arthropods perform to shed their rigid, heavy exoskeleton and permit body growth?

- A) Tagmatization
- B) Ecdysis (molting)
- C) Conjugation
- D) Metamerism

2. What term describes the specialized body regions formed by the fusion of segments in arthropods?

- A) Metameres
- B) Tagmata
- C) Ossicles
- D) Epitokes

3. How is oxygen delivered directly to cells in most terrestrial arthropods?

- A) Through a closed system of blood vessels with hemoglobin
- B) Through an efficient tracheal system of air tubes
- C) By diffusion through a calcareous shell
- D) Via a water vascular system

4. Which subphylum of arthropods is distinguished as being the ONLY group possessing two pairs of antennae?

- A) Subphylum Chelicerata
- B) Subphylum Hexapoda
- C) Subphylum Crustacea
- D) Subphylum Myriapoda

Answer Key

- ****1. B**** — Ecdysis (molting) is the shedding of the exoskeleton required for an arthropod to grow.
- ****2. B**** — Tagmatization is the specialization of body segments into distinct functional regions called tagmata.
- ****3. B**** — Terrestrial arthropods transport oxygen directly to cells using an efficient tracheal system of air tubes.
- ****4. C**** — Crustaceans are uniquely characterized among arthropods by having two pairs of antennae.

Lesson 29: 29 Plant biodiversity

1. What is the primary distinction between Gymnosperms and Angiosperms as stated in the handout?

- A) Gymnosperms have flowers, while Angiosperms produce spores
- B) Gymnosperms have naked seeds, while Angiosperms are flowering plants
- C) Gymnosperms are unicellular, while Angiosperms are multicellular
- D) Gymnosperms use C4 photosynthesis, while Angiosperms use CAM

2. Where is the human population explosion causing the greatest encroachment into forested areas for arable land?

- A) Alpine tundras
- B) Tropical countries
- C) Polar ice caps
- D) Temperate deserts

3. What are "heirloom seeds" as defined in the source?

- A) Genetically modified seeds used in high-yield industrial farming
- B) Seeds that lack an embryo and cannot germinate
- C) Seeds of traditional importance that are not used in commercial agriculture and are stored in seed banks
- D) Fossilized plant seeds from the Cambrian period

4. What taxonomic method uses a short genetic marker in an organism's DNA to rapidly identify its species?

- A) Edman degradation
- B) DNA barcoding
- C) Shotgun assembly
- D) Microarray hybridization

Answer Key

- **1. B** — Gymnosperms produce naked seeds, whereas Angiosperms represent flowering plants.
- **2. B** — Population explosion in tropical countries leads to human encroachment into forested areas for arable land.
- **3. C** — Heirloom seeds are non-commercial traditional seeds preserved by farmers, gardeners, and seed banks.
- **4. B** — DNA barcoding uses short genetic markers to identify organisms at the species level.

Lesson 30: 30 History of Biodiversity

1. Approximately how many years of evolution have produced the Earth's current biodiversity?

- A) 100 million years
- B) 1 billion years
- C) 3.5 billion years
- D) 10 billion years

2. What major historical milestone marked the beginning of the Phanerozoic Eon 540 million years ago, during which nearly every multicellular phylum appeared?

- A) The Irish Potato Famine
- B) The Cambrian Explosion
- C) The Carboniferous Rainforest Collapse
- D) The HGP Initiative

3. Which event 251 million years ago is described as the worst mass extinction event in Earth's history?

- A) The Carboniferous collapse

- B) The Permian-Triassic extinction event
- C) The Devonian drought
- D) The Holocene glaciation

4. What is the best global estimate for total macroscopic species diversity on Earth, the vast majority of which are arthropods?

- A) 100,000 species
- B) 1 million species
- C) Approximately 9 million species
- D) 500 million species

Answer Key

- **1. C** — Earth's current biodiversity represents the outcome of 3.5 billion years of evolutionary history.
- **2. B** — The Cambrian explosion 540 million years ago saw the rapid appearance of almost all multicellular phyla.
- **3. B** — The Permian-Triassic extinction 251 million years ago was the most severe mass extinction event recorded.
- **4. C** — The best estimate for global macroscopic diversity is roughly 9 million species, dominated by arthropods.

Lesson 31: 31 Importance of Biodiversity

1. What percentage of the human food supply comes from just 20 kinds of plants?

- A) 20%
- B) 50%
- C) 80%
- D) 95%

2. According to the text, what percentage of the world's population uses medicines derived from nature?

- A) 20%
- B) 50%
- C) 65%
- D) 80%

3. How many total plant species do humans use for food, clothing, and shelter?

- A) 20 species
- B) 500 species
- C) 40,000 species
- D) 1,000,000 species

4. What term describes a philosophical concept of value independent of something's value to anyone or anything else?

- A) Extrinsic value
- B) Intrinsic value
- C) Commercial value
- D) Ecosystem value

Answer Key

- **1. C** — 80% of the human food supply is derived from 20 kinds of plants.
- **2. D** — Natural medicines account for usage by 80% of the global population.
- **3. C** — Humans utilize approximately 40,000 species for food, clothing, and shelter.
- **4. B** — Intrinsic value refers to the value of something independent of its usefulness to others.

Lesson 32: 32 Modern plant breeding

1. What alternative name is given to the application of biotechnology or molecular biology in plant breeding?

- A) Classical selection
- B) Molecular breeding
- C) Recombinant taxonomy
- D) Cytological hybridization

2. In modern plant breeding, what approach allows desirable traits to be directly inserted into plants?

- A) Edman degradation
- B) Genetic modification
- C) Natural stratification
- D) Radiocarbon mutagenesis

3. Which scientific field provides the advanced facilities now used for selecting or inserting traits in plant breeding?

- A) Paleontology
- B) Molecular biology
- C) Macro-ecology
- D) Comparative anatomy

4. What are plants called when they result from inserting a specific gene or genes into their genome?

- A) Cisgenic plants
- B) Transgenic plants
- C) Heirloom plants
- D) Protoplast hybrids

Answer Key

- **1. B** — Applying biotechnology or molecular biology to plant breeding is termed molecular breeding.
- **2. B** — Genetic modification is utilized to insert or modify specific desirable traits in plants.
- **3. B** — Modern facilities in molecular biology are used to select and insert plant traits.
- **4. B** — Plants produced by adding foreign genes are referred to as transgenic plants.

Lesson 33: 33 Reasons for Loss of biodiversity

1. Which four factors comprise the "evil quartet" of biodiversity loss identified by Jared Diamond?

- A) Deforestation, pollution, soil erosion, and desertification
- B) Overkill, habitat destruction, secondary extinctions, and introduced species
- C) C3 pathways, C4 pathways, CAM pathways, and photorespiration
- D) Mutation, migration, genetic drift, and natural selection

2. According to expert estimates cited in the source, what percentage of all species on Earth could become extinct by 2050 due to habitat reduction?

- A) 10%
- B) 30%
- C) 50%
- D) 75%

3. According to the International Union for Conservation of Nature (IUCN), what proportion of all known species globally are threatened?

- A) One tenth
- B) One fourth
- C) About one third
- D) Over one half

4. What percentage of global fisheries are currently being overfished at unsustainable levels?

- A) Over 5%
- B) Over 10%
- C) Over 25%
- D) Over 80%

Answer Key

- ****1. B**** — Jared Diamond classified overkill, habitat destruction, secondary extinctions, and introduced species as the "evil quartet".
- ****2. B**** — Habitat loss leads experts to estimate that roughly 30% of species could be extinct by 2050.
- ****3. C**** — The IUCN states that globally about one third of known species are threatened.
- ****4. C**** — Overexploitation has resulted in over 25% of global fisheries being overfished.

Lesson 34: 34 Plant conservation

1. Which national park is explicitly cited as the first Reserve Forest in Pakistan?

- A) Margalla Hills National Park
- B) Ayubia National Park
- C) Chitral Gol National Park
- D) Khunjerab National Park

2. What is listed as a direct consequence of deforestation on soil quality?

- A) Increase in soil organic nitrogen
- B) Soil erosion and decrease in soil fertility leading to desertification
- C) Formation of permafrost layers
- D) Elimination of topsoil salinity

3. How does deforestation contribute to flooding according to the text?

- A) By increasing ocean basin depths

- B) By decreasing the water holding capacity of the soil
- C) By eliminating all atmospheric water vapor
- D) By neutralizing water table acidity

4. What term is defined as the restocking of destroyed forests by planting new trees?

- A) Afforestation
- B) Reforestation
- C) Deforestation
- D) Desertification

Answer Key

- **1. B** — Ayubia National Park is highlighted as the first Reserve Forest in Pakistan.
- **2. B** — Deforestation causes soil erosion and fertility loss, leading to desertification.
- **3. B** — A decrease in the soil's water holding capacity due to deforestation leads to floods.
- **4. B** — Reforestation is defined as restocking destroyed forests by planting new trees.

Lesson 35: 35 Plant breeding and Improvement

1. Early plant domestication and plant breeding practices are estimated to date back how many years?

- A) 1,000 to 2,000 years
- B) 5,000 to 6,000 years
- C) 9,000 to 11,000 years
- D) 20,000 to 25,000 years

2. Modern bread wheat is a mixture of recombined genes from how many wild species?

- A) Two
- B) Three
- C) Five
- D) Seven

3. Whose experiments with plant hybridization established the fundamental laws of inheritance?

- A) Jared Diamond
- B) Edward Wilson
- C) Gregor Mendel
- D) Willi Hennig

4. What genetic process does classical plant breeding primarily rely on during crossbreeding to generate diversity?

- A) Mass spectrometry
- B) Homologous recombination between chromosomes
- C) Shotgun sequence assembly
- D) Trans-alignment

Answer Key

- **1. C** — Plant breeding began with agriculture and domestication 9,000 to 11,000 years ago.

- **2. B** — Bread wheat contains recombined genes from three distinct wild species.
- **3. C** — Gregor Mendel's hybridization experiments established the laws of inheritance.
- **4. B** — Classical breeding relies on homologous recombination between chromosomes to create genetic variation.

Lesson 36: 36 Genetic Diversity in Ecosystem Management

1. How is genetic diversity defined within a population according to the source?

- A) The total biomass of species per square kilometer
- B) The variation at the level of individual genes, where a population contains most possible alleles for each locus
- C) The total number of different phyla present in an ecosystem
- D) The rate of primary productivity in tropical rainforests

2. Which of the following is NOT listed in the source as one of the four main factors responsible for the loss of genetic diversity in small populations?

- A) Genetic drift
- B) Founder effect
- C) Demographic bottleneck
- D) Photosynthetic photon flux

3. What is the direct genetic consequence of inbreeding within small populations?

- A) It increases overall heterozygosity
- B) It increases homozygosity and decreases heterozygosity
- C) It eliminates all point mutations
- D) It prevents speciation events

4. How do artificial barriers such as highways and dams affect genetic diversity among populations?

- A) They increase random genetic drift in large mainland areas
- B) They cause artificial isolation, avoiding natural genetic flux between populations
- C) They induce immediate polyploidy in plants
- D) They create high rates of beneficial mutations

Answer Key

- **1. B** — Genetic diversity refers to variation at the level of individual genes and possessing most possible alleles at a gene locus.
- **2. D** — The four factors listed for genetic diversity loss in small populations are genetic drift, founder effect, demographic bottleneck, and inbreeding.
- **3. B** — Inbreeding increases homozygosity and thereby decreases heterozygosity in small populations.
- **4. B** — Artificial barriers like highways and dams cause artificial isolation, preventing natural gene flux between populations.

Lesson 37: 37 in situ and ex situ conservation

1. What is the fundamental distinction between *in situ* and *ex situ* conservation?

- A) *In situ* conserves species in their natural habitat, whereas *ex situ* conserves them isolated from their natural habitat
- B) *In situ* applies only to plants, whereas *ex situ* applies only to animals
- C) *In situ* relies on genetic modification, whereas *ex situ* relies on classical breeding
- D) *In situ* is exclusively managed by zoos, whereas *ex situ* is managed in national parks

2. Why did the captive breeding reintroduction experiment for the Hawaiian goose (*Nene*) fail?

- A) The geese were unable to locate freshwater sources
- B) The original threat (rats) had not been eliminated and ate the eggs and nestlings
- C) Inbreeding depression produced 100% sterile offspring
- D) The geese failed to adapt to C3 photosynthetic plants

3. Under what controlled conditions can seeds in seed banks be maintained for decades or centuries?

- A) 50% humidity and 25°C
- B) Less than 5% humidity and -20°C
- C) 100% humidity and 0°C
- D) Ambient room temperature and full sunlight

4. What protection status is designated by CITES Appendix 1?

- A) Limited exploitation subject to quotas
- B) Total ban on exploitation
- C) Species requiring protection in certain states only
- D) Unregulated commercial trade permitted

Answer Key

- **1. A** — *In situ* conservation protects species in their natural habitat, while *ex situ* conserves species outside their natural environment.
- **2. B** — The experiment failed because introduced rats were not eliminated and consumed the eggs and nestlings.
- **3. B** — Seed viability is maintained over decades when stored at under 5% humidity and -20°C.
- **4. B** — CITES Appendix 1 places a total ban on the exploitation of listed endangered species.

Lesson 38: 38 Physiology of Microbial life

1. Which famous dictum regarding microbial distribution was formulated by Martinus Beijerinck around 1890?

- A) "Omnis cellula e cellula"
- B) "Everything is everywhere, the environment selects"
- C) "Survival of the fittest in the tangled bank"
- D) "One gene, one polypeptide"

2. Which ecological law states that growth is dictated by the single scarcest or growth-limiting resource?

- A) Shelford's Law of Tolerance
- B) Liebig's Law of the Minimum
- C) Darwin's Principle of Divergence

D) Hennig's Cladistic Rule

3. Which of the following is categorized as a negative microbial interaction in the text?

- A) Commensalism
- B) Protocooperation
- C) Amensalism
- D) Mutualism

4. Which bacterial genus is explicitly cited in the handout as an example of a microbial predator?

- A) *Escherichia*
- B) *Bdellovibrio*
- C) *Sinorhizobium*
- D) *Alcanivorax*

Answer Key

- **1. B** — Martinus Beijerinck formulated the classic microbial ecology principle: "Everything is everywhere, the environment selects".
- **2. B** — Liebig's Law of the Minimum states that growth is limited by the scarcest necessary resource.
- **3. C** — Amensalism is categorized alongside competition, predation, and parasitism as a negative interaction.
- **4. B** — *Bdellovibrio* is specifically cited as a predatory bacterium.

Lesson 39: 39 Evolution of Microbial Life

1. According to the endosymbiont hypothesis, from which group of bacteria did eukaryotic cells acquire aerobic respiration (mitochondria)?

- A) Cyanobacteria
- B) Alpha-proteobacteria
- C) Extreme halophiles
- D) Spirochetes

2. According to the endosymbiont hypothesis, chloroplasts were acquired through the engulfment of which organisms?

- A) Alpha-proteobacteria
- B) Cyanobacteria
- C) Methanogens
- D) Archaea

3. Which structural feature presents a major challenge to the endosymbiotic theory due to its 9+2 protein strand arrangement in eukaryotes compared to single strands in prokaryotes?

- A) Plasma membrane
- B) Flagella
- C) Peptidoglycans wall
- D) Ribosomal 16S subunit

4. What term describes neutral or harmless genotype variations that accumulate over time and randomly become dominant via genetic drift?

- A) Cryptic changes
- B) Macrolesions
- C) Frameshift mutations
- D) Polyploid aberrations

Answer Key

- **1. B** — Mitochondria and aerobic respiration were acquired from an engulfed alpha-proteobacterium.
- **2. B** — Chloroplasts were derived from photosynthetic cyanobacteria engulfed by early eukaryotes.
- **3. B** — Eukaryotic flagella have a complex 9+2 microtubule arrangement, making their origin difficult to explain via endosymbiosis.
- **4. A** — Neutral changes in genotype are described as "cryptic" variations that can become dominant through genetic drift.

Lesson 40: 40 Origin of life

1. Why does spontaneous generation of life NOT occur on Earth today according to Pasteur's principles?

- A) Oxygen destroys all organic molecules instantly
- B) The necessary prebiotic environmental conditions no longer exist
- C) All enzymes are inactivated by solar radiation
- D) DNA cannot form without nuclear membranes

2. What chemical structures were critical in defining the boundaries of the first cells by forming lipid bilayers in water?

- A) Peptidoglycans
- B) Phospholipids
- C) Polysaccharides
- D) Nucleosomes

3. Approximately how many years ago did free oxygen begin accumulating in Earth's atmosphere due to photosynthetic bacterial activity?

- A) 500 million years ago
- B) 1 billion years ago
- C) 2 billion years ago
- D) 4.5 billion years ago

4. What term refers to the natural process by which life arises from non-living matter, such as simple organic compounds on prebiotic Earth?

- A) Abiogenesis
- B) Conjugation
- C) Ecdysis
- D) Parthenogenesis

Answer Key

- **1. B** — Spontaneous generation does not occur today because the unique conditions of prebiotic Earth no longer exist.

- **2. B** — Phospholipids naturally form lipid bilayers in aqueous environments, encapsulating early cellular components.
- **3. C** — Photosynthetic bacterial activity led to free atmospheric oxygen around 2 billion years ago.
- **4. A** — Abiogenesis is the origin of life from non-living chemical precursors on prebiotic Earth.

Lesson 41: 41 Phylogeny and the Tree of Life

1. What is defined as the evolutionary history of a species or group of related species?

- A) Systematics
- B) Phylogeny
- C) Taxonomy
- D) Cladistics

2. Which discipline classifies organisms and determines their evolutionary relationships using fossil, molecular, and genetic data?

- A) Systematics
- B) Histology
- C) Cytology
- D) Ecology

3. In the Linnaean hierarchical classification system, what is the correct order of taxonomic categories from broad to narrow?

- A) Kingdom, Domain, Class, Phylum, Order, Genus, Family, Species
- B) Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species
- C) Species, Genus, Family, Order, Class, Phylum, Kingdom, Domain
- D) Domain, Phylum, Class, Kingdom, Order, Family, Genus, Species

4. Which proposed classification system recognizes only taxonomic groups that include a common ancestor and all its descendants?

- A) Binomial nomenclature
- B) PhyloCode
- C) Linnaean taxonomy
- D) Cladistic ranking

Answer Key

- **1. B** — Phylogeny is defined as the evolutionary history of a species or group of related species.
- **2. A** — Systematics is the discipline that classifies organisms and determines their evolutionary relationships.
- **3. B** — The taxonomic groups from broad to narrow are domain, kingdom, phylum, class, order, family, genus, and species.
- **4. B** — Systematists proposed the PhyloCode, which recognizes only monophyletic groups containing an ancestor and all its descendants.

Lesson 42: 42 Shared characters are used to construct phylogenetic trees

1. What type of clade consists of an ancestral species and ALL of its descendants?

- A) Paraphyletic
- B) Polyphyletic
- C) Monophyletic
- D) Outgroup

2. Which grouping consists of an ancestral species and some, but NOT all, of its descendants?

- A) Monophyletic
- B) Paraphyletic
- C) Polyphyletic
- D) Ingroup

3. In cladistic analysis, what is the primary function of comparing an ingroup with an outgroup?

- A) To measure total DNA sequence length
- B) To differentiate between shared derived and shared ancestral characteristics
- C) To calculate metabolic rates
- D) To observe microscopic cell divisions

4. Which principle assumes that the phylogenetic tree requiring the fewest evolutionary events is the most likely?

- A) Maximum likelihood
- B) Maximum parsimony
- C) Phylogenetic bracketing
- D) Natural selection

Answer Key

- **1. C** — A monophyletic clade consists of an ancestral species and all of its descendants.
- **2. B** — A paraphyletic group consists of an ancestral species and some, but not all, of its descendants.
- **3. B** — Comparing ingroup species with an outgroup differentiates shared derived characters from shared ancestral characters.
- **4. B** — Maximum parsimony assumes that the tree requiring the fewest evolutionary events is the most likely.

Lesson 43: 43 Phylogenetic Trees as Hypotheses

1. What method allows scientists to predict features of an ancestor by analyzing features of its descendants?

- A) Maximum likelihood
- B) Phylogenetic bracketing
- C) Molecular barcoding
- D) Shotgun sequence assembly

2. Analysis of slowly evolving ribosomal RNA (rRNA) genes indicates that which two domains are most closely related?

- A) Bacteria and Archaea
- B) Eukarya and Archaea
- C) Bacteria and Eukarya
- D) Protista and Monera

3. Why are ribosomal RNA (rRNA) genes particularly useful for constructing the deepest branches of the tree of life?

- A) They mutate rapidly in every generation
- B) They have evolved relatively slowly over time
- C) They are present only in multicellular animals
- D) They form lipid bilayer cell membranes

4. What alternative model may better depict early evolutionary relationships if eukaryotes arose from endosymbiosis between a bacterium and an archaean?

- A) Chain of being
- B) Ring of life
- C) Ladder of classification
- D) Linear lineage

Answer Key

- **1. B** — Phylogenetic bracketing allows researchers to infer features of an ancestor from features of its descendants.
- **2. B** — Sequence data from rRNA genes indicates that eukaryotes and archaea are more closely related to each other than to bacteria.
- **3. B** — Ribosomal RNA genes are used for deep evolutionary trees because they have evolved slowly.
- **4. B** — If eukaryotes arose via endosymbiosis between a bacterium and an archaean, the relationship is depicted as a ring of life.

Lesson 44: 44 Natural Selection

1. According to Darwin's theory, what is the primary mechanism responsible for evolutionary change in populations?

- A) Genetic drift
- B) Natural selection
- C) Abiogenesis
- D) Artificial gene duplication

2. What term describes inherited characteristics of organisms that enhance their survival and reproduction in specific environments?

- A) Adaptations
- B) Vestigial structures
- C) Macro-mutations
- D) Homoplasies

3. In evolutionary biology, how is an individual organism's fitness defined?

- A) Its body size and muscle mass
- B) Its reproductive contribution of offspring or genes to future generations
- C) Its ability to survive without water
- D) The number of chromosomes in its genome

4. Natural selection leads to evolutionary change because individuals with certain inherited traits experience what?

- A) Equal reproductive success regardless of environment
- B) Higher rates of survival and reproduction compared to others
- C) Instantaneous polyploidy
- D) Loss of all cell membrane proteins

Answer Key

- **1. B** — Darwin proposed that natural selection is the primary mechanism driving evolutionary change.
- **2. A** — Adaptations are inherited characteristics that enhance survival and reproduction in specific environments.
- **3. B** — Evolutionary fitness is measured by an individual's reproductive contribution of offspring or genes to future generations.
- **4. B** — Natural selection occurs when individuals with advantageous traits produce more surviving offspring.

Lesson 45: 45 Evidence for evolution

1. What term refers to structural similarity between different species resulting from common ancestry?

- A) Analogy
- B) Homology
- C) Homoplasy
- D) Convergence

2. Which of the following describes analogous structures?

- A) Structures that share common embryonic origin but different adult functions
- B) Structures that share similar function but not common structural ancestry, having evolved independently
- C) Features that have no function in any living or extinct species
- D) Chromosomes that pair during meiosis

3. What are vestigial structures?

- A) Newly evolved organ systems in extreme environments
- B) Features with no apparent current function that had important roles in ancestors or related species
- C) Enzymes that catalyze DNA replication
- D) Pigments used in C4 photosynthesis

4. Which of the following is explicitly listed in the handout as a vestigial structure in humans?

- A) Appendix
- B) Biceps tendon
- C) Cornea
- D) Thyroid gland

Answer Key

- **1. B** — Homology refers to structural similarity in different species derived from a common ancestor.
- **2. B** — Analogous structures share function but not structural similarity because they evolved independently.

- **3. B** — Vestigial structures are features with no current apparent function that were important in ancestors.
- **4. A** — Wisdom teeth, tailbone, and the appendix are listed as human vestigial structures.

Lesson 46: 46 Human Evolution

1. To which order of mammals do humans belong, consisting of about 180 species that diverged 80–65 million years ago?

- A) Carnivora
- B) Primates
- C) Rodentia
- D) Cetacea

2. Which species is identified in the handout as the first bipedal hominid, found in East Africa dating to about 3.0–3.2 million years ago?

- A) *Homo erectus*
- B) *Homo habilis*
- C) *Australopithecus afarensis*
- D) *Homo neanderthalensis*

3. According to the source, what are the four major steps involved in the evolution of modern humans from hominid ancestors?

- A) Photosynthesis, multicellularity, segmentation, and flight
- B) Evolving terrestriality, bipedalism, encephalization (large brain), and civilization
- C) Tagmatization, ecdysis, metamorphosis, and predation
- D) Endosymbiosis, abiogenesis, polyploidy, and conjugation

4. What is unique about human evolution regarding abiotic environmental pressures?

- A) Humans lost the ability to perform aerobic cellular respiration
- B) Humans evolved the power to alter their environment to protect themselves from abiotic pressures
- C) Humans eliminated all genetic mutations from their genome
- D) Humans reverted from bipedalism back to quadrupedal knuckle-walking

Answer Key

- **1. B** — Humans belong to the order Primates, an old mammalian order comprising roughly 180 species.
- **2. C** — *Australopithecus afarensis* was the first bipedal hominid, discovered in East Africa dating to 3.0–3.2 MYBP.
- **3. B** — Human evolution from hominid ancestors involved four key steps: terrestriality, bipedalism, brain enlargement, and civilization.
- **4. B** — Humans evolved intellect and culture, allowing them to modify their environment and alter their own selective pressures.

Lesson 47: 47 Proterozoic Eon

1. How long is the Proterozoic Eon, and what percentage of all geologic time does it represent?

- A) 545 million years long (10% of geologic time)
- B) 1.955 billion years long (42.5% of geologic time)

- C) 3.5 billion years long (80% of geologic time)
- D) 100 million years long (5% of geologic time)

2. Spheroidal and filamentous bacterial microfossils from the Early Proterozoic were discovered in which rock formation in Ontario, Canada?

- A) Grand Canyon Shales
- B) Gunflint Chert
- C) Burgess Shale
- D) Ediacaran Hills

3. Why was organic diversity relatively limited during the era dominated exclusively by prokaryotes?

- A) Prokaryotes lacked plasma membranes
- B) Prokaryotes reproduce asexually, lacking the gene shuffling characteristic of sexual reproduction
- C) Prebiotic Earth contained no organic carbon sources
- D) High atmospheric oxygen levels eliminated all mutations

4. What are Acritarchs, the common Late Proterozoic microfossils mentioned in the source?

- A) Fossilized bones of early aquatic vertebrates
- B) Likely cysts of algae representing evidence of early eukaryotic organisms
- C) Chitinous exoskeletons of primitive arthropods
- D) Preserved viral capsids in deep marine sediments

Answer Key

- **1. B** — The Proterozoic Eon spans 1.955 billion years, accounting for 42.5% of total geologic time.
- **2. B** — The Gunflint Chert of Ontario, Canada, contains famous Early Proterozoic spheroidal and filamentous bacterial fossils.
- **3. B** — Prokaryotes reproduce asexually, whereas gene shuffling during sexual reproduction generates greater organic diversity.
- **4. B** — Acritarchs are common Late Proterozoic microfossils identified as probable algal cysts from early eukaryotes.

Lesson 48: 48 evolutionary biodiversity in Proterozoic Eon

1. According to the source, how did eukaryotic cells originate during the Proterozoic Eon?

- A) Through spontaneous generation from inorganic mineral beds
- B) Through endosymbiosis involving symbiotic relationships among several prokaryotic cells
- C) By viral transduction of whole animal chromosomes
- D) By the sudden emergence of calcified skeletons

2. What is highlighted as a primary physical limitation of single-celled organisms compared to multicellular organisms?

- A) Single-celled organisms cannot replicate nucleic acids
- B) Single-celled organisms cannot grow very large
- C) Single-celled organisms lack cell membranes
- D) Single-celled organisms cannot survive in aqueous environments

3. What structural feature characterized virtually all known animal life during the Proterozoic Eon prior to the Cambrian period?

- A) Heavy chitinous jointed exoskeletons
- B) Soft-bodied forms lacking durable skeletons
- C) Calcified vertebral columns
- D) Silica shells like diatoms

4. When did durable skeletons made of silica, calcium carbonate, and chitin first appear in abundance in the fossil record?

- A) At the start of the HGP initiative in 1990
- B) At the beginning of the Phanerozoic Eon (~545 million years ago, in the Cambrian)
- C) 3.5 billion years ago on prebiotic Earth
- D) During the Permian-Triassic extinction event

Answer Key

- **1. B** — Eukaryotic cells originated via endosymbiosis among prokaryotic cells in prolonged symbiotic relationships.
- **2. B** — For 1.5 billion years life was single-celled, but single-celled organisms are limited because they cannot grow very large.
- **3. B** — Proterozoic animals were soft-bodied, preceding the mass appearance of hard skeletons.
- **4. B** — Skeletons made of silica, calcium carbonate, and chitin appeared in abundance at the start of the Phanerozoic Eon (545 MYA).

Lesson 49: 49 Evolution of definition of Ecology

1. What are the Greek root words from which the term "Ecology" is derived, and what do they mean?

- A) *Bios* (life) and *Logos* (word)
- B) *Oikos* ("at home") and *Ology* ("the study of")
- C) *Physis* (nature) and *Clados* (branch)
- D) *Genos* (gene) and *Nomos* (law)

2. Who defined ecology in 1927 as "Scientific natural history"?

- A) Ernst Haeckel
- B) Charles Elton
- C) Eugene Odum
- D) H.G. Andrewartha

3. Which sub-discipline is defined as designing industrial infrastructure as a series of interlocking "technological ecosystems" interfacing with natural ecosystems?

- A) Landscape Ecology
- B) Industrial Ecology
- C) Restoration Biology
- D) Urban Ecology

4. According to the source, how is "Sustainability" defined?

- A) Maximizing fossil fuel consumption in urban infrastructure

- B) A property of human society in which ecosystems are managed so conditions supporting present-day life on Earth can continue
- C) Eliminating all predators from marine food webs
- D) Converting all natural biomes into agricultural pastures

Answer Key

- **1. B** — Ecology is derived from the Greek root *oikos* ("at home") and *ology* ("the study of").
- **2. B** — Charles Elton defined ecology in 1927 as "Scientific natural history".
- **3. B** — Industrial ecology designs industrial infrastructure as technological ecosystems using natural ecosystem patterns for sustainability.
- **4. B** — Sustainability is managing ecosystems so that conditions supporting present-day life on Earth continue.

Lesson 50: 50 Levels of studying ecology

1. In the hierarchical levels of ecological study, how is a "Population" defined?

- A) All living and non-living factors on Earth combined
- B) A group of interacting and interbreeding organisms of a single species
- C) Large-scale continental vegetation zones defined by macroclimates
- D) An individual cell's internal organelles

2. Which level of ecological study is defined as "interacting populations which significantly affect each other's distributions and abundance"?

- A) Biome
- B) Ecosystem
- C) Community
- D) Biosphere

3. How does the text define an "Ecosystem"?

- A) A single isolated nucleotide base sequence
- B) A set of organisms and abiotic components connected by the exchange of matter and energy
- C) The total number of extinct species in a fossil bed
- D) A collection of non-interacting individuals of different phyla

4. Which level represents the largest ecological scale, encompassing Earth's ecosystem interacting with the physical environment as a whole?

- A) Biome
- B) Biosphere
- C) Guild
- D) Microclimate

Answer Key

- **1. B** — A population is defined as a group of interacting and interbreeding organisms of a single species.
- **2. C** — A community consists of interacting populations that significantly affect each other's distribution and abundance.
- **3. B** — An ecosystem consists of organisms and abiotic components connected by the exchange of matter and energy.

- **4. B** — The biosphere is the Earth's ecosystem interacting with the physical environment as a whole to maintain a steady-state system.

Lesson 51: 51 Natural history

1. Which fundamental distinction among animal groups was introduced by the French naturalist Jean-Baptiste Lamarck?

- A) Autotrophs and heterotrophs
- B) Vertebrates and invertebrates
- C) Prokaryotes and eukaryotes
- D) Annelids and arthropods

2. Before becoming a professor responsible for insects, worms, and microscopic animals at the Museum of Natural History in Paris, how did Lamarck begin his scientific career?

- A) As a paleontologist
- B) As a botanist
- C) As a marine biologist
- D) As a geologist

3. According to the handout, assessing the Index of Biological Integrity depends on detailed natural history knowledge of which organism group?

- A) Regional fish faunas
- B) Deep-sea crustaceans
- C) Desert reptiles
- D) Soil fungi

4. At the Museum of Natural History in Paris, which group of organisms was Lamarck specifically responsible for teaching and researching?

- A) Gymnosperms, angiosperms, and bryophytes
- B) Insects, worms, and microscopic animals
- C) Birds, mammals, and reptiles
- D) Algae, lichens, and mosses

Answer Key

- **1. B** — Lamarck introduced the fundamental distinction between vertebrates and invertebrates.
- **2. B** — Lamarck originally began his scientific career as a botanist before taking his professorship in Paris.
- **3. A** — The Index of Biological Integrity relies on thorough natural history knowledge of regional fish faunas.
- **4. B** — At the museum in Paris, Lamarck was appointed professor for insects, worms, and microscopic animals.

Lesson 52: 52 Life in Water

1. What percentage of the total water in the biosphere is held within the Earth's oceans?

- A) 50%
- B) 75%
- C) 88%

D) 97%

2. Out of all the water in the biosphere, what percentage remains as freshwater once oceans, polar ice caps, and glaciers are excluded?

- A) Less than 1%
- B) Approximately 5%
- C) Exactly 10%
- D) Over 15%

3. In aquatic environments, light attenuation restricts photosynthetic organisms to which specific water zone?

- A) Abyssal zone
- B) Euphotic (epipelagic) zone
- C) Hadal benthic zone
- D) Sub-surface aphotic zone

4. Where are kelp forests predominantly distributed according to the source?

- A) Tropical equatorial regions
- B) Temperate latitudes
- C) Polar ice caps
- D) Deep ocean trenches

Answer Key

- **1. D** — The biosphere's oceans contain 97% of all Earth's water.
- **2. A** — Excluding oceans (97%) and ice caps/glaciers (2%), less than 1% of water exists as freshwater.
- **3. B** — Light restriction limits photosynthetic life to the euphotic or epipelagic zone.
- **4. B** — Kelp forests are mainly found at temperate latitudes, whereas coral reefs are tropical.

Lesson 53: 53 temperature relations

1. Which global factors interact to generate Earth's macroclimate?

- A) Tidal pull and ocean currents
- B) Uneven heating of Earth's surface by the sun and Earth's permanent axis tilt
- C) Volcanic activity and atmospheric nitrogen levels
- D) Tectonic plate movement and ground color

2. Macroclimate interacts with local landscape features—such as altitude, aspect, vegetation, and burrows—to produce what?

- A) Biomes
- B) Microclimates
- C) Global wind belts
- D) Geothermal gradients

3. At the molecular level, how do extreme environmental temperatures negatively impact an organism's performance?

- A) By degrading ribosomal RNA subunits
- B) By impairing the functioning of enzymes
- C) By preventing lipid bilayer formation

D) By dissolving cell walls

4. Why are most endothermic aquatic species air breathers rather than water breathers?

- A) Water contains no dissolved oxygen
- B) The physical nature of the aquatic environment reduces options for body temperature regulation
- C) Aquatic plants absorb all available water heat
- D) Water pressure destroys internal lungs

Answer Key

- **1. B** — Macroclimate is produced by the sun's uneven heating and the Earth's permanent axial tilt.
- **2. B** — Interaction between macroclimate and local landscape features creates microclimates.
- **3. B** — Thermal extremes impair enzyme function at the molecular level, altering performance.
- **4. B** — The physical properties of water constrain thermoregulation, making aquatic endotherms air breathers.

Lesson 54: 54 Water Relations

1. What physical process governs the availability of water to organisms in both terrestrial and aquatic environments?

- A) Movement of water down concentration gradients
- B) Active transport by ion pumps
- C) Thermal expansion of ocean water
- D) Capillary action in igneous rock

2. How is relative humidity calculated according to the handout?

- A) Saturation vapor density minus actual vapor density
- B) Water vapor density divided by saturation water vapor density multiplied by 100
- C) Total rainfall divided by annual temperature
- D) Vapor pressure deficit multiplied by 10

3. On land, which parameter approximates the tendency of water to evaporate from organisms into the surrounding atmosphere?

- A) Index of Biological Integrity
- B) Vapor pressure deficit
- C) Osmotic potential index
- D) Photosynthetic yield ratio

4. How is the vapor pressure deficit of air calculated?

- A) Water vapor density divided by 100
- B) The difference between actual water vapor pressure and saturation water vapor pressure
- C) The sum of relative humidity and ground altitude
- D) Atmospheric pressure minus soil water density

Answer Key

- **1. A** — Water movement down concentration gradients determines its availability to organisms.
- **2. B** — Relative humidity is water vapor density divided by saturation water vapor density times 100.
- **3. B** — Vapor pressure deficit approximates the evaporative movement of water from organisms to air.

- **4. B** — Vapor pressure deficit is calculated as the difference between actual and saturation water vapor pressures.

Lesson 55: 55 Energy and Nutrient Relations

1. What are the three primary energy sources utilized by living organisms?

- A) Heat, wind, and water current
- B) Light, inorganic molecules, and organic molecules
- C) Carbon, nitrogen, and phosphorus
- D) Ultraviolet radiation, magnetic fields, and gravity

2. Photosynthetic plants and algae absorb light energy within which specific wavelength spectrum?

- A) 100 to 300 nm
- B) 400 to 700 nm
- C) 750 to 1000 nm
- D) 1100 to 1500 nm

3. What compound do photosynthetic plants and algae use as their carbon source?

- A) Carbon monoxide (CO)
- B) Carbon dioxide (CO₂)
- C) Methane (CH₄)
- D) Glucose (C₆H₁₂O₆)

4. Which tiger beetle species is cited as being strictly restricted to cool boreal and mountain environments due to climatic factors?

- A) *Cicindela longilabris*
- B) *Loxosceles reclusa*
- C) *Folsomia candida*
- D) *Orchesella cincta*

Answer Key

- **1. B** — Organisms derive energy from light, inorganic molecules, or organic molecules.
- **2. B** — Photosynthesis utilizes light wavelengths between 400 and 700 nm.
- **3. B** — Photosynthetic organisms fix CO₂ as their primary carbon source.
- **4. A** — The tiger beetle *Cicindela longilabris* is restricted to cool boreal and mountain habitats.

Lesson 56: 56 Social Relation

1. What process results from differences in reproductive rates among individuals due to variation in mating success?

- A) Natural local adaptation
- B) Sexual selection
- C) Genetic drift
- D) Abiogenesis

2. How does intrasexual selection differ from intersexual selection?

- A) Intrasexual selection involves mate choice by one sex, whereas intersexual selection involves competition among the same sex
- B) Intrasexual selection involves competition among individuals of the same sex, whereas intersexual selection involves mate choice by one sex
- C) Intrasexual selection occurs only in plants, whereas intersexual selection occurs only in animals
- D) Intrasexual selection increases mortality, whereas intersexual selection eliminates all mutations

3. Which of the following is considered the pinnacle of social evolution in social species?

- A) Commensalism
- B) Eusociality
- C) Amensalism
- D) Mutualism

4. Which of the following is NOT one of the three major characteristics defining eusociality?

- A) Individuals of more than one generation living together
- B) Cooperative care of young
- C) Division of individuals into sterile and reproductive castes
- D) Obligate C4 photosynthetic metabolism in all workers

Answer Key

- **1. B** — Sexual selection results from differences in reproductive rates among individuals due to differences in their mating success.
- **2. B** — Intrasexual selection operates through competition among individuals of the same sex, while intersexual selection operates through mate choice by one sex.
- **3. B** — Eusociality is considered the pinnacle of social evolution in animal societies.
- **4. D** — Eusociality is defined by multi-generational living, cooperative brood care, and sterile/reproductive caste division.

Lesson 57: 57 Population Genetics

1. According to the Hardy-Weinberg principle, what happens to allele frequencies in a population over time?

- A) They double with each generation due to mutation
- B) They remain constant in a population mating at random in the absence of evolutionary forces
- C) They decline to zero as carrying capacity is reached
- D) They fluctuate unpredictably due to obligate inbreeding

2. For a population in Hardy-Weinberg equilibrium with two alleles at a particular locus (p and q), what equation represents the allele frequencies?

- A) $p \times q = 100$
- B) $p + q = 1.0$
- C) $p^2 - q^2 = 0$
- D) $r = \ln(R_0) / T$

3. Which of the following is a required condition for a population to maintain Hardy-Weinberg equilibrium?

- A) High rate of beneficial mutations
- B) Small population size subject to severe genetic drift

- C) Random mating
- D) Strong natural selection favoring heterozygotes

4. What is the sum of all genetic variation carried by individuals in an interbreeding population called?

- A) Genome tree
- B) Gene pool
- C) Trophosome
- D) Clade

Answer Key

- **1. B** — The Hardy-Weinberg principle states that allele frequencies remain constant in a random-mating population without evolutionary forces.
- **2. B** — In Hardy-Weinberg equilibrium for two alleles at a locus, the sum of their frequencies is $(p + q = 1.0)$.
- **3. C** — Maintaining Hardy-Weinberg equilibrium requires random mating alongside the absence of evolutionary forces like selection or mutation.
- **4. B** — The sum of all genetic variation present within an interbreeding population is defined as its gene pool.

Lesson 58: 58 Population Distribution and Abundance

1. How do ecologists define a population?

- A) All living organisms and abiotic factors across a continent
- B) A group of individuals of a single species inhabiting an area delimited by natural or human-imposed boundaries
- C) A collection of non-interacting species in a laboratory culture
- D) The total number of extinct species recorded in a fossil bed

2. What pattern of spatial distribution is typically exhibited by territorial organisms on small scales?

- A) Random distribution
- B) Regular distribution
- C) Clumped distribution
- D) Exponential distribution

3. On small spatial scales, what type of distribution pattern is fostered when environmental resources are patchy?

- A) Regular distribution
- B) Clumped distribution
- C) Uniform distribution
- D) Sigmoidal distribution

4. In general, how does animal population density relate to increasing organism size?

- A) Population density increases with increasing organism size
- B) Population density declines with increasing organism size
- C) Population density remains completely unaffected by organism size
- D) Population density doubles for every unit increase in body mass

Answer Key

- **1. B** — A population is defined as a group of individuals of a single species inhabiting a specific delimited area.
- **2. B** — Territorial organisms tend to be regularly spaced on small spatial scales.
- **3. B** — Patchy environmental resources foster clumped spatial distributions among organisms.
- **4. B** — Animal population density generally declines as organism body size increases.

Lesson 59: 59 Population Dynamics

1. Which type of survivorship curve is characterized by a fairly constant probability of mortality throughout an organism's life?

- A) Type I survivorship
- B) Type II survivorship
- C) Type III survivorship
- D) Type IV survivorship

2. How is the net reproductive rate ($\sum l_x m_x$) calculated from a life table and fecundity schedule?

- A) By dividing total population size by generation time
- B) By multiplying age-specific survivorship (l_x) by age-specific birthrate (m_x) and summing the results ($\sum l_x m_x$)
- C) By subtracting death rate from birth rate
- D) By taking the natural logarithm of carrying capacity

3. What does a Type III survivorship curve indicate about a population's mortality pattern?

- A) High mortality among the young and low mortality among older individuals
- B) Low mortality among the young and high mortality among older individuals
- C) Equal mortality across all age classes
- D) Zero mortality until maximum lifespan is reached

4. Which mathematical relationship defines the per capita rate of increase (r)?

- A) $r = \ln(R_0) / T$
- B) $r = p + q$
- C) $r = \sum l_x m_x$
- D) $r = N_c / N_e$

Answer Key

- **1. B** — Type II survivorship is defined by a constant rate of mortality throughout the organism's lifespan.
- **2. B** — Net reproductive rate ($\sum l_x m_x$) is calculated as the sum of age-specific survivorship times age-specific birthrates ($\sum l_x m_x$).
- **3. A** — Type III survivorship curves reflect high mortality in early life stages followed by high survival among older individuals.
- **4. A** — Per capita rate of increase (r) relates to net reproductive rate (R_0) and generation time (T) by the formula $r = \ln(R_0) / T$.

Lesson 60: 60 Population Growth

1. Which population growth model describes continuous growth with overlapping generations, such as in human or bacterial populations?

- A) Geometric model
- B) Exponential model
- C) Static life table model
- D) Cladistic model

2. What term describes the maximum population size that a particular environment can support as resources become depleted?

- A) Intrinsic rate of increase ((r_m))
- B) Carrying capacity ((K))
- C) Net reproductive rate ((R_0))
- D) Effective population size ((N_e))

3. What shape does a population growth curve take when modeled by the logistic growth equation?

- A) Linear straight line
- B) Sigmoidal or S-shaped curve
- C) U-shaped curve
- D) Inverse bell-shaped curve

4. In general, how does an organism's intrinsic rate of increase ((r_m)) correlate with its body size?

- A) (r_m) increases with increasing body size
- B) (r_m) decreases with increasing body size
- C) (r_m) remains identical across all organism sizes
- D) (r_m) is highest in large vertebrate animals

Answer Key

- **1. B** — Exponential growth models continuous population growth in organisms with overlapping generations.
- **2. B** — Carrying capacity is the maximum number of individuals of a population that the environment can support.
- **3. B** — Resource limitation causes population growth to slow and produce a sigmoidal or S-shaped logistic curve.
- **4. B** — Intrinsic rate of increase ((r_m)) generally decreases as organism body size increases.

Lesson 61: 61 Competition

1. How is competition between individuals of different species defined in ecological terms?

- A) Intraspecific competition
- B) Interspecific competition
- C) Interference mutualism
- D) Exploitative facilitation

2. What form of competition involves direct aggressive interactions between individuals?

- A) Resource competition
- B) Interference competition
- C) Indirect competition

D) Apparent competition

3. In herbaceous plant populations, what process reflects competition for resources as population density increases?

- A) Ecdysis
- B) Self-thinning
- C) Eusociality
- D) Conjugation

4. Which of the following is explicitly listed as one of the four essential design features for a valid field experiment?

- A) Complete removal of all soil microbes
- B) Knowledge of initial conditions
- C) Continuous satellite remote sensing
- D) Artificial polyploidy induction

Answer Key

- **1. B** — Interspecific competition is defined as competition between individuals of different species.
- **2. B** — Interference competition involves direct aggressive interactions between competing individuals.
- **3. B** — Self-thinning in plant populations reflects resource competition for water, light, and nutrients as density increases.
- **4. B** — A valid field experiment requires a testable hypothesis, knowledge of initial conditions, controls, and replication.

Lesson 62: 62 Exploitation

1. How is exploitation defined in interspecific interactions?

- A) Interactions that benefit both partners equally
- B) Interactions between species that enhance the fitness of one individual at the expense of another
- C) Neutral interactions where neither species is affected
- D) Mating competition between individuals of the same sex

2. Which four categories of species interactions are grouped under the heading of exploitation?

- A) Mutualism, Commensalism, Amensalism, and Neutralism
- B) Herbivory, Predation, Parasitism, and Disease
- C) Speciation, Extinction, Migration, and Mutation
- D) C3, C4, CAM, and PAR

3. What distinguishes parasitoids from typical parasites?

- A) Parasitoids do not infect living hosts
- B) Parasitoids routinely kill their host as a part of their development
- C) Parasitoids are exclusively autotrophic photosynthetic plants
- D) Parasitoids live only in deep ocean hydrothermal vents

4. According to exploitative interaction principles, how does an exploiting species benefit from the relationship?

- A) By increasing the host's reproductive rate
- B) By enhancing its own fitness while reducing the fitness of the host or prey

- C) By eliminating all competitive exclusion in the biome
- D) By stabilizing atmospheric carbon dioxide levels

Answer Key

- **1. B** — Exploitation encompasses interactions where one organism enhances its fitness at another's expense.
- **2. B** — Herbivory, predation, parasitism, and disease are the four major categories classified as exploitation.
- **3. B** — Parasitoids differ from parasites because their developmental process ultimately consumes and kills the host.
- **4. B** — An exploiter species increases its own fitness by drawing resources from a host or prey, lowering the host's fitness.

Lesson 63: 63 Mutualism

1. What defines a mutualistic interaction between two individuals?

- A) An interaction that harms one partner while benefiting the other
- B) An interaction that benefits both partners
- C) An interaction that reduces the fitness of both partners
- D) An interaction where one partner is unaffected and the other is harmed

2. How does facultative mutualism differ from obligate mutualism?

- A) In facultative mutualism, species can live without their partners, whereas in obligate mutualism they cannot survive without them
- B) Facultative mutualism occurs only in aquatic environments, whereas obligate mutualism occurs on land
- C) Facultative mutualism is harmful to both species, whereas obligate mutualism is neutral
- D) Facultative mutualism involves a predator and prey, whereas obligate mutualism involves two autotrophs

3. In the mutualistic relationship between the honeyguide bird and human honey gatherers, what specific information does the honeyguide communicate?

- A) The time of day and temperature of the hive
- B) The direction, distance, and arrival at bees' nests
- C) The total number of worker bees in the colony
- D) The chemical composition of the beeswax

4. What role has mutualism played in the biosphere according to the text?

- A) It caused the Permian-Triassic mass extinction
- B) It has made key contributions to the evolutionary history of life and ecological integrity of the biosphere
- C) It eliminated the need for primary production in plants
- D) It prevents nitrogen cycling in terrestrial soils

Answer Key

- **1. B** — Mutualism is an interaction between individuals that results in mutual benefits for both partners.

- **2. A** — Species in facultative mutualisms can survive independently, whereas obligate mutualists depend on each other for survival.
- **3. B** — Honeyguides inform human gatherers of the direction, distance, and arrival location of bees' nests.
- **4. B** — Mutualistic interactions have contributed significantly to evolutionary history and global ecological integrity.

Lesson 64: 64 Specie Abundance and Diversity

1. What term do animal ecologists use to describe a group of species that all make their living in a similar way?

- A) Life-form
- B) Guild
- C) Clade
- D) Biome

2. What shape do Frank Preston's (1948) lognormal distributions take when graphing species abundance intervals?

- A) Linear straight line
- B) Bell-shaped curve
- C) U-shaped curve
- D) Sigmoidal step curve

3. Which two major factors combine to define the species diversity of a community?

- A) Primary productivity and biomass density
- B) Species richness and species evenness
- C) Mutation rate and genetic drift
- D) Latitude and longitude

4. What did Robert MacArthur (1958) discover regarding warbler species diversity in North American forests?

- A) Warbler diversity decreases as foliage height diversity increases
- B) Warbler species diversity increases with increasing foliage height diversity and forest stature
- C) All five warbler species feed in the exact same layer of forest vegetation
- D) Warblers rely strictly on C4 photosynthetic seeds for nutrition

Answer Key

- **1. B** — Animal ecologists use the term "guild" for groups of species that utilize resources in similar ways.
- **2. B** — Preston's lognormal distributions of species abundance form characteristic bell-shaped curves.
- **3. B** — Species diversity combines species richness (number of species) with species evenness (relative abundances).
- **4. B** — MacArthur found that warbler diversity increases with foliage height diversity as species feed in different forest layers.

Lesson 65: 65 Food Webs

1. What does a food web summarize in an ecological community?

- A) The total rainfall and solar radiation
- B) The feeding relations in a community
- C) The rate of gene flow between populations
- D) The mineral composition of soil layers

2. Where was the earliest research on food webs primarily concentrated?

- A) Tropical rainforests of South America
- B) Simplified communities in areas such as Arctic islands
- C) Hydrothermal vents in pelagic trenches
- D) Agricultural citrus orchards in Asia

3. What did Robert Paine (1966) propose regarding the influence of keystone species on community structure?

- A) Keystone predators reduce species diversity by causing competitive exclusion
- B) The feeding activities of a few keystone species can control community structure and increase diversity by preventing competitive exclusion
- C) Keystone species always have the largest biomass in an ecosystem
- D) Keystone species are exclusively herbivorous insects

4. Which organism was manipulated in marine intertidal studies to demonstrate keystone predator control over community structure?

- A) Honeyguide
- B) Starfish
- C) Tiger beetle
- D) Kudzu vine

Answer Key

- **1. B** — A food web summarizes the feeding relationships among species within a community.
- **2. B** — Early food web studies focused on simplified community structures in Arctic islands.
- **3. B** — Paine proposed that keystone predators maintain community diversity by suppressing dominant competitors and preventing competitive exclusion.
- **4. B** — Experimental removal of starfish in marine intertidal zones demonstrated their role as keystone predators.

Lesson 66: 66 Primary Production and Energy Flow

1. What is primary production in an ecosystem?

- A) The consumption of organic material by secondary carnivores
- B) The fixation of energy by autotrophs
- C) The breakdown of dead organic matter by decomposers
- D) The evaporation of water off a terrestrial landscape

2. What is Net Primary Production (NPP)?

- A) The total amount of energy fixed by all autotrophs in an ecosystem
- B) The amount of energy left over after autotrophs have met their own energetic needs
- C) The amount of energy lost as heat during respiration at higher trophic levels
- D) The total biomass of heterotrophs supported in a food web

3. Which single measure combines temperature and moisture conditions to predict terrestrial net primary production?

- A) Relative humidity
- B) Annual Actual Evapotranspiration (AET)
- C) Vapor pressure deficit
- D) Index of Biological Integrity

4. In aquatic ecosystems, what factor generally limits primary production?

- A) Soil depth
- B) Nutrient availability
- C) Earth's axial tilt
- D) Atmospheric pressure

Answer Key

- **1. B** — Primary production is defined as the fixation of energy by autotrophs in an ecosystem.
- **2. B** — Net primary production is the energy remaining after autotrophs satisfy their own energetic requirements.
- **3. B** — Annual Actual Evapotranspiration (AET) combines temperature and moisture and positively correlates with terrestrial net primary production.
- **4. B** — Primary production in aquatic ecosystems is generally limited by nutrient availability.

Lesson 67: 67 Nutrient Cycling and Retention

1. How do ecosystem ecologists define "nutrient cycling"?

- A) The total input of solar radiation onto a landscape
- B) The use, transformation, movement, and reuse of elements required for development, maintenance, and reproduction
- C) The rapid loss of soil organic matter due to desertification
- D) The evolutionary divergence of species tree nodes

2. What term describes the length of stream required for an atom of a nutrient to complete a cycle?

- A) Trophic distance
- B) Spiraling length
- C) Successional turnover
- D) Fragmentation scale

3. What effect does disturbance typically have on nutrient retention in forest ecosystems?

- A) It permanently prevents all water evaporation
- B) It increases nutrient loss from ecosystems
- C) It stops all microbial nitrogen fixation
- D) It doubles the soil organic depth immediately

4. Direct correlation has been shown between nitrate export by major rivers and which human factor?

- A) Industrial carbon tax rates
- B) Human population density

- C) Number of national parks
- D) Average elevation of the catchment area

Answer Key

- **1. B** — Nutrient cycling is defined as the use, transformation, movement, and reuse of nutrients in ecosystems.
- **2. B** — Spiraling length is the length of stream required for a nutrient atom to complete one full cycle.
- **3. B** — Disturbance increases the loss of nutrients from terrestrial ecosystems.
- **4. B** — Nitrate concentration and export by the earth's major rivers correlate directly with human population density.

Lesson 68: 68 Succession and Stability

1. What is primary succession?

- A) The recovery of a forest community on intact soil after a mild wildfire
- B) Gradual change in plant and animal communities on newly exposed geological substrates not significantly modified by organisms
- C) The seasonal migration of animals between tropical biomes
- D) The artificial introduction of invasive species into an island ecosystem

2. How does secondary succession differ from primary succession?

- A) Secondary succession occurs where disturbance destroys a community without destroying the soil
- B) Secondary succession occurs only in deep ocean trenches
- C) Secondary succession occurs without any species change over time
- D) Secondary succession takes millions of years to show any increase in species diversity

3. Which of the following ecosystem properties increases during succession at Glacier Bay?

- A) Atmospheric pressure
- B) Soil depth, organic content, moisture, and nitrogen
- C) Rate of soil erosion
- D) Frequency of volcanic eruptions

4. What technique is used by ecologists to detect long-term ecological changes occurring over very long periods?

- A) Repeat photography
- B) Edman degradation
- C) Shotgun sequence assembly
- D) PCR amplification

Answer Key

- **1. B** — Primary succession occurs on newly exposed geological substrates not modified by organisms.
- **2. A** — Secondary succession takes place in areas where a disturbance destroys a community but leaves the soil intact.
- **3. B** — Ecosystem changes during succession at Glacier Bay include increases in soil depth, organic content, moisture, and nitrogen.

- **4. A** — Repeat photography is a valuable tool used to detect long-term ecological changes over extended periods.

Lesson 69: 69 Landscape Ecology

1. How is a "landscape" defined in landscape ecology?

- A) A single uniform stand of C3 agricultural crops
- B) A heterogeneous area composed of several ecosystems forming a mosaic of distinctive patches
- C) A deep-sea pelagic zone with constant salinity
- D) An artificial greenhouse environment

2. What are the visually distinctive ecosystem patches that make up a landscape called?

- A) Tagmata
- B) Landscape elements
- C) Trophosomes
- D) Clades

3. Which area of mathematics is used today to quantify the structure of complex natural shapes in landscapes?

- A) Euclidean geometry
- B) Fractal geometry
- C) Matrix algebra
- D) Calculus of variations

4. What does "landscape structure" include?

- A) Only the molecular weight of soil enzymes
- B) The size, shape, composition, number, and position of different ecosystems within a landscape
- C) The number of chromosomes in regional plant species
- D) The rate of atmospheric nitrogen fixation in oceans

Answer Key

- **1. B** — A landscape is a heterogeneous area made up of several ecosystems arranged in a mosaic of distinctive patches.
- **2. B** — Visually distinctive patches that form a landscape mosaic are called landscape elements.
- **3. B** — Fractal geometry is used by landscape ecologists to quantify complex natural shapes and landscape structures.
- **4. B** — Landscape structure includes the size, shape, composition, number, and position of different ecosystems within a landscape.

Lesson 70: 70 Geographic Ecology

1. What is the main focus of geographic ecology?

- A) Analyzing the primary structure of individual proteins
- B) Large-scale patterns of distribution and diversity of organisms
- C) Intracellular organelle movements during mitosis
- D) Mating behaviors within single insect colonies

2. How does species richness generally respond to island area?

- A) Species richness decreases as island area increases
- B) Species richness increases with increasing island area
- C) Species richness remains completely constant regardless of area
- D) Species richness drops to zero on islands larger than 100 square kilometers

3. How does isolation affect species richness on islands and continental habitat patches?

- A) Species richness increases with greater isolation
- B) Species richness decreases with increasing isolation
- C) Isolation has no effect on species richness
- D) Isolation doubles the net primary productivity of the island

4. Which famous theory in geographic ecology addresses species richness on islands based on area and isolation?

- A) The Hardy-Weinberg equilibrium model
- B) The Theory of Island Biogeography
- C) The Endosymbiont theory
- D) The Central Dogma of Molecular Biology

Answer Key

- **1. B** — Geographic ecology focuses on large-scale patterns of distribution and diversity of organisms across geographic scales.
- **2. B** — Species richness on islands and habitat patches increases with area.
- **3. B** — Species richness decreases as the isolation of an island or habitat patch increases.
- **4. B** — The theory of island biogeography addresses how species richness on islands relates to area and isolation.

Lesson 71: 71-Competition**1. What principle states that two species with identical ecological requirements living in the same place cannot coexist indefinitely?**

- A) Competitive exclusion principle
- B) Intermediate disturbance hypothesis
- C) Hardy-Weinberg equilibrium principle
- D) Optimal foraging theory

2. In David Tilman's diatom competition experiment, for which limiting resource did *Asterinella formosa* and *Synedra ulna* compete?

- A) Nitrogen
- B) Silica
- C) Phosphorus
- D) Iron

3. What was the outcome when *Asterinella formosa* and *Synedra ulna* were grown together under conditions of limited silica?

- A) Both species coexisted at equal densities
- B) *Asterinella formosa* drove *Synedra ulna* to extinction
- C) *Synedra ulna* reduced silica levels and drove *Asterinella formosa* to extinction
- D) Both species mutated into C4 autotrophs

4. Which of the following is an assumption of the competitive exclusion principle?

- A) Environmental conditions fluctuate constantly
- B) Competing species have completely different resource requirements
- C) Environmental conditions remain constant
- D) Predators continually eliminate superior competitors

Answer Key

- **1. A** — The competitive exclusion principle states that complete competitors with identical ecological requirements cannot coexist indefinitely.
- **2. B** — The diatoms *Asterionella formosa* and *Synedra ulna* compete specifically for silica required for cell wall formation.
- **3. C** — *Synedra ulna* efficiently reduced silica to a level too low for *Asterionella formosa*, driving it to extinction.
- **4. C** — Key assumptions of the competitive exclusion model are that resource requirements are identical and environmental conditions remain constant.

Lesson 72: 72-Competition**1. According to the hypothesis proposed by Grubb and Tilman, under what soil conditions do plants compete most intensively for mineral nutrients?**

- A) When mineral nutrients are highly abundant in the soil
- B) When mineral nutrients are less abundant in the soil
- C) When the soil is completely flooded with freshwater
- D) When plants utilize C4 photosynthesis exclusively

2. What does Grime and Keddy's hypothesis propose regarding plant competition in resource-poor habitats?

- A) Competition is most intense when water and nutrients are scarce
- B) Competition is less intense when water and nutrients are less abundant because plants are widely spaced
- C) Plants always eliminate neighbors through direct chemical warfare
- D) Belowground competition is completely replaced by light competition

3. What fundamental difference distinguishes Grubb and Tilman's hypothesis from Grime and Keddy's hypothesis?

- A) The use of rDNA sequences versus protein mass spectrometry
- B) The relative importance placed on belowground (nutrients) versus aboveground (light) resource competition
- C) The inclusion of viral vectors in plant gene transfer
- D) The assumption that all plants are obligate parasites

4. In salt marsh plant zonation studies, what environmental factor sets the lower zonal borders of plant species distribution?

- A) Interspecific competition
- B) Physical stress such as soil salinity and anoxia
- C) Herbivory by leafhoppers
- D) Optimal foraging by wading birds

Answer Key

- **1. B** — Grubb and Tilman hypothesized that plant competition for soil nutrients is most intense when mineral nutrients are scarce.
- **2. B** — Grime and Keddy proposed that low nutrient/water levels limit growth so plants remain widely spaced, making competition less intense.
- **3. B** — The core debate between these hypotheses centers on the relative importance of belowground (nutrient) versus aboveground (light) competition.
- **4. B** — Physical stress factors like soil salinity and anoxia set lower zonation borders, while competition sets upper borders.

Lesson 73: 73-Competition

1. How does interspecific competition affect the equilibrium population level of a competing species compared to its environmental carrying capacity?

- A) It increases the equilibrium level above carrying capacity
- B) It reduces the equilibrium level below carrying capacity
- C) It has no effect on population equilibrium
- D) It doubles the intrinsic rate of increase

2. According to the Lotka-Volterra competition model, what condition leads to stable coexistence between two competing species?

- A) Interspecific competition is stronger than intraspecific competition
- B) Each species inhibits its own population growth more than it inhibits the competitor's growth
- C) Species 1 completely eliminates Species 2 regardless of initial density
- D) Environmental conditions fluctuate violently every generation

3. In the Lotka-Volterra model, what determines which species wins in an outcome characterized by unstable equilibrium?

- A) The initial population abundances of the competing species
- B) The total concentration of atmospheric nitrogen
- C) The presence of a keystone predator
- D) The mutation rate of ribosomal RNA genes

4. How many distinct possible outcomes of interspecific competition are derived from the Lotka-Volterra competition equations?

- A) Two
- B) Four
- C) Six
- D) Ten

Answer Key

- **1. B** — Interspecific competition depresses the population equilibrium level below the species' carrying capacity.
- **2. B** — Stable coexistence occurs when intraspecific competition is stronger than interspecific competition, so each species limits itself more than its competitor.

- **3. A** — In unstable equilibrium, interspecific competition is strong for both, and the winning species depends on initial population sizes.
- **4. B** — The Lotka-Volterra competition model defines four distinct outcomes based on relative competitive strengths.

Lesson 74: 74-Competition

1. What type of competition occurs when organisms indirectly interact by consuming the same limited resources?

- A) Interference competition
- B) Exploitation competition
- C) Apparent mutualism
- D) Intrasexual selection

2. How is interference competition defined in interspecific interactions?

- A) Indirect competition through resource depletion without physical contact
- B) Direct interactions where organisms prevent others from occupying a habitat or accessing resources
- C) Symbiotic transfer of genes between bacterial cells
- D) Random fluctuations in allele frequencies in small populations

3. Which of the following is an example of exploitation competition?

- A) Male deer fighting directly with antlers for territory
- B) Two zebra species indirectly competing by grazing on the same grass patch
- C) Birds actively defending nest cavities from competitors
- D) Ants physically blocking the entrance of a competing colony's nest

4. How can predators or consumers alter the outcome of competitive interactions between prey species?

- A) By preventing any prey species from undergoing cell division
- B) By suppressing dominant competitors and preventing competitive exclusion among prey
- C) By forcing all prey species to adopt C4 photosynthetic pathways
- D) By eliminating intraspecific competition while increasing gene flow

Answer Key

- **1. B** — Exploitation competition involves indirect interaction through shared consumption of limiting resources.
- **2. B** — Interference competition involves direct behavioral or physical prevention of access to habitat or resources.
- **3. B** — Zebras grazing on the same grass represent exploitation competition because they affect each other indirectly through resource depletion.
- **4. B** — Consumers can modify competition outcomes by reducing the abundance of dominant competitors, allowing coexistence.

Lesson 75: 75-Energy and Nutrient Relations

1. What are the three primary energy sources utilized by living organisms according to the source?

- A) Heat, wind, and water currents
- B) Light, inorganic molecules, and organic molecules
- C) Ultraviolet light, gamma rays, and magnetism
- D) Glucose, starch, and cellulose

2. Within what wavelength range does Photosynthetically Active Radiation (PAR) fall?

- A) 100 to 300 nm
- B) 400 to 700 nm
- C) 750 to 1200 nm
- D) 1500 to 2000 nm

3. How is Photosynthetically Active Radiation (PAR) quantified in ecological measurements?

- A) As Net Primary Productivity in kilograms per hectare
- B) As photosynthetic photon flux density
- C) As Actual Evapotranspiration in millimeters per year
- D) As relative humidity percentage

4. How do C4 and CAM plants compare to C3 plants regarding water use efficiency?

- A) C4 and CAM plants are less efficient in water use than C3 plants
- B) C4 and CAM plants are more efficient in water use than C3 plants
- C) All three photosynthetic pathways have identical water use efficiency
- D) CAM plants require 100 times more water than C3 plants

Answer Key

- **1. B** — Organisms derive energy from three primary sources: light, inorganic molecules, or organic molecules.
- **2. B** — Photosynthetically Active Radiation (PAR) comprises light wavelengths between 400 and 700 nm.
- **3. B** — PAR is quantified as photosynthetic photon flux density, measured in micromol/m²/s.
- **4. B** — C4 and CAM photosynthetic pathways allow plants to fix carbon with greater water use efficiency than C3 plants.

Lesson 76: 76-Energy and Nutrient Relations

1. What do detritivores feed on, which is characterized by having lower nitrogen content than living plant material?

- A) Fresh animal tissues
- B) Dead organic plant material
- C) Synthetic mineral salts
- D) Dissolved atmospheric gases

2. What primary compositional imbalance do herbivores face when feeding on plant tissues?

- A) High nitrogen and low carbon
- B) High carbon and low nitrogen
- C) High silica and zero carbohydrates
- D) High iron and low water content

3. What obstacle must herbivores overcome in addition to low nitrogen content when feeding on plants?

- A) Complete lack of cell membranes
- B) Physical and chemical defenses of plants
- C) High body temperatures of plant leaves
- D) Absence of photosynthetic enzymes in foliage

4. Which three groups of heterotrophs face fundamentally different trophic problems based on their food sources?

- A) Autotrophs, phototrophs, and chemolithotrophs
- B) Herbivores, carnivores, and detritivores
- C) C3 plants, C4 plants, and CAM plants
- D) Archaea, Bacteria, and Eukarya

Answer Key

- **1. B** — Detritivores feed on dead plant material, which contains even lower nitrogen levels than living plant tissue.
- **2. B** — Plant tissues consumed by herbivores typically contain a great deal of carbon but relatively little nitrogen.
- **3. B** — Herbivores must overcome physical and chemical plant defenses to acquire nutrients.
- **4. B** — Heterotrophs face distinct trophic challenges categorized by herbivory, carnivory, and detritivory.

Lesson 77: 77-Rate of uptake of energy**1. What theory attempts to model how organisms feed as an optimizing process?**

- A) Hardy-Weinberg equilibrium theory
- B) Optimal foraging theory
- C) Theory of island biogeography
- D) Endosymbiont theory

2. According to evolutionary ecologists, what does natural selection favor when organisms have limited access to energy?

- A) Individuals that reproduce asexually without meiosis
- B) Individuals that are more effective at acquiring energy and nutrients
- C) Individuals that maximize body size at the expense of survival
- D) Individuals that eliminate all internal metabolic enzymes

3. How do many animals select their food according to optimal foraging predictions?

- A) By choosing food randomly regardless of energy content
- B) In a way that maximizes the rate at which they capture energy
- C) By avoiding all organic carbon sources
- D) By feeding only during peak solar radiation

4. How do plants adjust their energy allocation between roots and shoots when facing limiting resources?

- A) They stop all growth in both roots and shoots
- B) They allocate energy in a way that increases their rate of intake of the limiting resource

- C) They convert all root cells into photosynthetic shoots
- D) They shed all leaves and store energy exclusively in seeds

Answer Key

- **1. B** — Optimal foraging theory models organism feeding behavior as an energy-optimizing process.
- **2. B** — Under energy limitation, natural selection favors individuals that efficiently acquire energy and nutrients.
- **3. B** — Animals typically select food items in a manner that maximizes their net rate of energy capture.
- **4. B** — Plants allocate energy between roots and shoots to maximize uptake of whichever resource is most limiting.

Lesson 78: 78-Evaluating Molecular Homologies

1. What tools do systematists use when analyzing comparable DNA segments across different organisms?

- A) Light microscopes and Edman degradation
- B) Computer programs and mathematical tools
- C) Radioisotope counters and fossil sieves
- D) Spectrophotometers and pH meters

2. In molecular systematics, what are coincidences or accidental base matches between DNA sequences called?

- A) Molecular homologies
- B) Molecular homoplasies
- C) Monophyletic clades
- D) Paraphyletic groupings

3. What must systematists carefully distinguish when analyzing molecular sequence similarities between taxa?

- A) Exons from introns
- B) Homology from analogy
- C) Genotype from phenotype
- D) Mitosis from meiosis

4. What type of data does molecular systematics primarily utilize to determine evolutionary relationships?

- A) Macroclimate topographic maps
- B) DNA and other molecular data
- C) Fossilized bone density measurements
- D) Soil nitrogen turnover rates

Answer Key

- **1. B** — Systematists utilize computer algorithms and mathematical models to align and compare DNA sequences.
- **2. B** — Accidental or non-homologous sequence alignments are termed molecular homoplasies.
- **3. B** — Accurately inferring phylogenies requires distinguishing true molecular homologies from non-ancestral analogies.

- **4. B** — Molecular systematics relies on DNA, RNA, and protein sequence data to infer evolutionary relationships.

Lesson 79: 79-Shared Ancestral and Shared Derived Characters

1. What defines a shared ancestral character in cladistic analysis?

- A) An evolutionary novelty unique to a single terminal species
- B) A character that originated in an ancestor of the taxon
- C) A trait that evolved independently through convergent analogy
- D) A gene mutation that causes immediate lethality

2. What is a shared derived character?

- A) A character present in all domains of life since abiogenesis
- B) An evolutionary novelty unique to a particular clade
- C) A vestigial organ with no functional role
- D) A non-coding intron sequence removed during splicing

3. In cladistics, what is an out-group?

- A) A species that is completely unrelated to any living animal phylum
- B) A species or group of species closely related to the in-group being studied
- C) A fossil taxon from an earlier geological eon
- D) An artificial hybrid produced in laboratory cultures

4. Why do systematists compare in-group species with an out-group?

- A) To measure total cellular respiration rates
- B) To differentiate between shared derived and shared ancestral characteristics
- C) To calculate the rate of soil erosion
- D) To synthesize lipid membranes in vitro

Answer Key

- **1. B** — A shared ancestral character is a trait inherited from an ancestor prior to the divergence of the clade.
- **2. B** — A shared derived character is an evolutionary novelty unique to a specific clade.
- **3. B** — An out-group is a closely related taxon outside the group under study used for character comparison.
- **4. B** — Out-group comparison allows systematists to determine whether a character state is ancestral or derived.

Lesson 80: 80-Shared Ancestral and Shared Derived Characters

1. What do homologies shared by both the out-group and in-group represent?

- A) Derived characters unique to the in-group
- B) Ancestral characters that predate the divergence of both groups from a common ancestor
- C) Molecular homoplasies caused by random mutation
- D) Analogous traits formed by environmental adaptation

2. Why can a single character be considered both ancestral and derived depending on context?

- A) Because all characters mutate at identical rates
- B) Because whether it is ancestral or derived depends on the specific clade being evaluated
- C) Because characters change during an individual's lifetime
- D) Because out-groups contain no genetic information

3. What assumption underlies the principle of maximum parsimony in building phylogenetic trees?

- A) The most likely tree requires the maximum number of evolutionary steps
- B) The tree that requires the fewest evolutionary events is the most likely
- C) Tree branch lengths must all be identical in length
- D) Mutation rates must be zero across all lineages

4. What does the principle of maximum likelihood state regarding phylogenetic tree construction?

- A) All trees are equally probable regardless of DNA sequence data
- B) Given rules about DNA change over time, a tree can be found reflecting the most likely sequence of evolutionary events
- C) Only morphological traits should be used to construct trees
- D) Trees must form a complete closed ring of life

Answer Key

- **1. B** — Characters shared between in-group and out-group are ancestral features predating their divergence.
- **2. B** — Character designation depends on context, relative to the node where the trait first evolved.
- **3. B** — Maximum parsimony chooses the tree that minimizes the total number of evolutionary changes required.
- **4. B** — Maximum likelihood identifies the tree topology that makes observed sequence data most probable under a model.

Lesson 81: 81-Evolution of Definitions of Ecology

1. Which 1870 definition by Ernst Haeckel describes ecology?

- A) The study of all low molecular weight cellular constituents
- B) The body of knowledge concerning the economy of Nature and the investigation of the total relations of the animal to its environment
- C) The classification of all phyla using molecular barcoding
- D) The study of gene duplication in yeast populations

2. In the 1890s, Burdon-Sanderson elevated Ecology to one of the three natural divisions of Biology alongside which two other divisions?

- A) Genetics and Paleontology
- B) Physiology and Morphology
- C) Cytology and Histology
- D) Systematics and Cladistics

3. Who defined ecology in 1927 as "Scientific natural history"?

- A) Eugene Odum
- B) Charles Elton
- C) H.G. Andrewartha

D) Ernst Haeckel

4. Who defined ecology in 1963 as "The structure and function of Nature"?

- A) Charles Elton
- B) Eugene Odum
- C) H.G. Andrewartha
- D) Burdon-Sanderson

Answer Key

- **1. B** — Ernst Haeckel (1870) defined ecology as the body of knowledge concerning the economy of Nature and an animal's total relations to its environment.
- **2. B** — Burdon-Sanderson recognized Physiology, Morphology, and Ecology as the three primary natural divisions of Biology.
- **3. B** — Charles Elton defined ecology as "Scientific natural history" in 1927.
- **4. B** — Eugene Odum defined ecology as "The structure and function of Nature" in 1963.

Lesson 82: 82-Ecological Economics

1. What is the primary objective of Ecological Economics?

- A) To maximize short-term industrial resource extraction
- B) To integrate ecology and economics so economic and environmental policies are reinforcing rather than mutually destructive
- C) To eliminate all financial institutions in developing nations
- D) To replace natural ecosystems entirely with artificial agricultural fields

2. How does Industrial Ecology approach industrial infrastructure design?

- A) By viewing nature as an infinite sink for industrial waste
- B) As a series of interlocking "technological ecosystems" interfacing with global natural ecosystems
- C) By eliminating all technology from human society
- D) By focusing exclusively on genetic modification of soil microbes

3. Unlike industrial ecology, what is the specific focus of Ecological Engineering?

- A) The complete eradication of all invasive predator species
- B) The manipulation of natural ecosystems by humans for human purposes using small amounts of supplemental energy
- C) The sequence alignment of ribosomal RNA genes across biomes
- D) The financial taxation of municipal wastewater facilities

4. What is the primary focus of Restoration Biology as described in the text?

- A) Application of ecosystem ecology to the restoration of deteriorated landscapes toward their original state
- B) Mapping microclimates using satellite remote sensing
- C) Performing Edman degradation on structural proteins
- D) Calculating the carrying capacity of marine fisheries

Answer Key

- **1. B** — Ecological Economics integrates ecology and economics so environmental and economic policies reinforce each other.

- **2. B** — Industrial Ecology designs industrial infrastructure as interlocking "technological ecosystems" patterned after natural processes.
- **3. B** — Ecological Engineering focuses on manipulating natural ecosystems for human goals using minimal supplemental energy.
- **4. A** — Restoration Biology applies ecosystem principles to restore deteriorated landscapes (such as prairie grass) back toward their original state.

Lesson 83: 83-Mutations

1. What defines a mutation in a cell's genome?

- A) The synthesis of ATP during cellular respiration
- B) Any change in the proper nucleic acid sequence of a specific gene
- C) The physical movement of water down a concentration gradient
- D) The fusion of two gametes during fertilization

2. How do environmental selective pressures affect beneficial mutations in a population?

- A) Beneficial mutations are immediately eliminated within one generation
- B) Beneficial mutations remain in the population across generations and drive evolution
- C) Selective pressures prevent beneficial mutations from affecting the phenotype
- D) Selective pressures convert all point mutations into macrolesions

3. Which category of mutation involves alterations to large sections of a DNA sequence?

- A) Microlesions
- B) Macrolesions
- C) Point substitutions
- D) Silent transitions

4. Which type of microlesion occurs when 1 or 2 base pairs are inserted or deleted, altering the reading frame?

- A) Inversion
- B) Frameshift mutation
- C) Duplication
- D) Translocation

Answer Key

- **1. B** — A mutation is defined as any change in the nucleic acid sequence of a gene in a cell's genome.
- **2. B** — Advantageous mutations under selective pressures persist across generations and drive evolutionary change.
- **3. B** — Macrolesions involve changes to large sections of DNA sequences (including deletions, insertions, inversions, and duplications).
- **4. B** — Insertions or deletions of 1 or 2 base pairs cause frameshift microlesions, altering the downstream reading frame.

Lesson 84: 84-Mutations

1. What is the baseline rate of uncorrected spontaneous microlesion mutations that remain after cellular correction mechanisms?

- A) 1 per hundred
- B) 1 per thousand
- C) 1 per million
- D) 1 per billion

2. Which of the following is listed as a primary mechanism that induces microlesion mutations?

- A) Actual evapotranspiration
- B) Chemical mutagens and radiation
- C) Osmotic potential gradients
- D) Natural selection in C3 plants

3. How can mobile genetic elements such as transposons cause mutations?

- A) By fixing atmospheric nitrogen into ammonium
- B) By rearranging genes between and within DNA molecules
- C) By preventing all DNA replication in daughter cells
- D) By dissolving cell walls in aquatic environments

4. What term describes harmless, neutral genotype changes that accumulate over time and randomly become dominant in a population?

- A) Selective sweeps
- B) Cryptic changes resulting in genetic drift
- C) Lethal macrolesions
- D) Destructive bottlenecks

Answer Key

- **1. D** — While spontaneous mismatches occur at roughly 1 per million, repair mechanisms correct most, leaving about 1 per billion uncorrected.
- **2. B** — Microlesions arise spontaneously or are induced by chemical mutagens and radiation.
- **3. B** — Mobile elements like transposons cause mutations by rearranging gene sequences between or within DNA molecules.
- **4. B** — Neutral or benign genetic variations are "cryptic" changes that can randomly achieve high frequency via genetic drift.

Lesson 85: 85-Genetic Recombination

1. What process allows two DNA molecules to exchange segments during eukaryotic meiosis?

- A) Binary fission
- B) Crossing over
- C) Edman degradation
- D) Transcription

2. What role do R plasmids play in bacterial populations?

- A) They carry transposons that rapidly spread antibiotic resistance genes within and between bacterial populations
- B) They synthesize C4 photosynthetic enzymes

- C) They digest cellulose in herbivore stomachs
- D) They regulate macroclimate temperature fluctuations

3. What term describes the lateral exchange of genetic material between independent bacterial cells?

- A) Vertical inheritance
- B) Horizontal Gene Transfer
- C) Phylogenetic bracketing
- D) Secondary succession

4. Which three mechanisms account for Horizontal Gene Transfer in bacteria?

- A) Mutation, Migration, and Genetic Drift
- B) Conjugation, Transformation, and Transduction
- C) Mitosis, Meiosis, and Fertilization
- D) Selection, Adaptation, and Speciation

Answer Key

- **1. B** — Crossing over is the process by which homologous DNA molecules exchange segments during eukaryotic meiosis.
- **2. A** — R plasmids carry transposons that disseminate antibiotic resistance genes among bacterial cells.
- **3. B** — Lateral exchange of genetic material between organisms is called Horizontal Gene Transfer.
- **4. B** — Horizontal gene transfer in bacteria occurs via three main mechanisms: conjugation, transformation, and transduction.

Lesson 86: 86-Evolutionary Biodiversity in Proterozoic Eon

1. What evolutionary development during the Early Proterozoic time significantly accelerated the pace of evolution and organic diversity?

- A) Asexual binary fission
- B) Sexual reproduction
- C) Polyploid endosymbiotic mutation
- D) Spontaneous abiogenesis

2. According to the source, how did eukaryotic cells originate during the Proterozoic Eon?

- A) Through spontaneous chemical reactions in prebiotic pools
- B) Through endosymbiosis involving prolonged symbiotic relationships among several prokaryotic cells
- C) By viral transformation of ancient archaeal cell walls
- D) Through radiocarbon decay in deep chert beds

3. What term describes neutral or benign genotype variations that accumulate over time and randomly become dominant in a population?

- A) Selective sweeps
- B) Cryptic changes resulting in genetic drift
- C) Macrolesion inversions
- D) Interspecific competition

4. Which mechanisms account for horizontal gene transfer and the recombination of completely new genes in prokaryotes?

- A) Mitosis, meiosis, and fertilization

- B) Conjugation, transformation, and transduction
- C) Transcription, translation, and splicing
- D) Self-thinning, ecdysis, and tagmatization

Answer Key

- **1. B** — Sexually reproducing cells evolved by Early Proterozoic time, increasing the tempo of evolution through gene shuffling.
- **2. B** — Eukaryotic cells originated via endosymbiosis involving prolonged symbiotic relationships among prokaryotes.
- **3. B** — Harmless or neutral genotype variations are termed "cryptic" changes that can become dominant through genetic drift.
- **4. B** — Horizontal gene transfer occurs via conjugation, transformation, and transduction in prokaryotes.

Lesson 87: 87-Dawn of Multicelled Organisms

1. Where were 2.1-billion-year-old fossils of carbonaceous filaments—believed to be early multicelled algae—discovered?

- A) Gunflint Chert in Ontario
- B) Negaunee Iron Formation in Michigan
- C) Bitter Springs Formation in Australia
- D) Grand Canyon Quartzite in Arizona

2. What physical constraint limits the maximum size that single-celled organisms can attain?

- A) Inability to synthesize peptidoglycan walls
- B) Decrease in the surface area to volume ratio as size increases, making material transfer less efficient
- C) Lack of Photosynthetically Active Radiation
- D) Excessive atmospheric oxygen concentrations

3. For approximately how many years in Earth's history were all living organisms exclusively single-celled?

- A) 100 million years
- B) 500 million years
- C) 1.5 billion years
- D) 3.5 billion years

4. Which of the following is explicitly listed as an evolutionary advantage of multicellularity?

- A) Immunity to all viral pathogens
- B) Longer lifespan because cells can be replaced and specialized into functional organs
- C) Total loss of cell membrane lipid bilayers
- D) Reliance on C4 photosynthetic carbon fixation

Answer Key

- **1. B** — Early multicelled algae fossils appearing as carbonaceous filaments were found in the 2.1-billion-year-old Negaunee Iron Formation in Michigan.
- **2. B** — As single cells grow larger, proportionately less cell surface is exposed relative to volume, reducing material transfer efficiency.

- **3. C** — For roughly 1.5 billion years, all living organisms on Earth were single-celled before multicelled forms appeared.
- **4. B** — Multicelled organisms live longer because damaged cells can be replaced and specialized into organs with specific capabilities.

Lesson 88: 88-Other Proterozoic Animal Fossils

1. What structural feature characterized virtually all known Proterozoic animals prior to the Cambrian period?

- A) Heavy, jointed silica exoskeletons
- B) Soft-bodied forms lacking durable skeletal structures
- C) Calcified vertebral columns
- D) Bony internal endoskeletons

2. Which animal from latest Proterozoic rocks in Russia possessed a tough outer covering and is interpreted as a sluglike or mollusk-like creature?

- A) *Kimberella*
- B) *Paramecium*
- C) *Ciona*
- D) *Orchesella*

3. When did durable skeletons made of silica, calcium carbonate, and chitin first appear in abundance in the fossil record?

- A) At the start of the Proterozoic Eon (2.5 billion years ago)
- B) At the beginning of the Phanerozoic Eon (~545 million years ago, Cambrian age)
- C) 2.1 billion years ago in the Negaunee Iron Formation
- D) During the Permian-Triassic extinction event (251 million years ago)

4. A jellyfish-like fossil impression was discovered in rocks located 200 meters below which famous Australian geological formation?

- A) Gunflint Chert
- B) Ediacara Hills
- C) Burgess Shale
- D) Grand Canyon Shales

Answer Key

- **1. B** — All known Proterozoic animals were soft-bodied prior to the mass emergence of mineralized skeletons.
- **2. A** — *Kimberella* is a latest Proterozoic Russian fossil with a tough outer covering, thought to be a sluglike or mollusk-like animal.
- **3. B** — Skeletons made of silica, calcium carbonate, and chitin appeared in abundance at the start of the Phanerozoic Eon (~545 MYA).
- **4. B** — A jellyfish-like impression was found 200 meters below the Ediacara Hills Pound Quartzite.

Lesson 89: 89-Exploitation

1. How is exploitation defined in interspecific ecological interactions?

- A) Interactions that benefit both participating species equally
- B) Interactions between species that enhance the fitness of one individual at the expense of another
- C) Competition between individuals of the same species for territory
- D) Neutral coexistence where neither species impacts the other

2. Which four major categories of interspecific interactions are grouped under the heading of exploitation?

- A) Mutualism, Commensalism, Amensalism, and Neutralism
- B) Predation, Herbivory, Parasites, and Disease
- C) Selection, Drift, Mutation, and Gene Flow
- D) Autotrophy, Heterotrophy, Chemotrophy, and Phototrophy

3. How does a pathogenic fungus manipulate its host plant to promote its own reproduction?

- A) By increasing the plant's seed yield tenfold
- B) By altering the plant's growth program to form "pseudoflowers," rendering the host plant sterile
- C) By converting the plant from C3 to C4 photosynthesis
- D) By stimulating root hair development to absorb excess nitrogen

4. In Sweden, a 70% reduction in the red fox population caused by a parasitic infestation resulted in what ecological outcome?

- A) Total collapse of all primary producers
- B) Increases in the abundance of several prey species previously eaten by foxes
- C) Immediate extinction of all small rodents
- D) A 90% drop in annual precipitation

Answer Key

- **1. B** — Exploitation encompasses interactions where one organism enhances its fitness at the expense of another.
- **2. B** — Predation, herbivory, parasites, and disease are the four major interaction types classified as exploitation.
- **3. B** — Pathogenic fungi manipulate host plant growth to produce "pseudoflowers" that promote fungal reproduction while sterilizing the plant.
- **4. B** — A parasite-driven 70% decline in red foxes led to increased abundances among prey species formerly eaten by foxes.

Lesson 90: 90-Ecological Relationships Ecological Relationships of Predator-prey, parasite-host, and pathogen-host Relationships**1. Which classical, well-studied example illustrates long-term population cycles driven by the combined effects of food availability and predator pressure?**

- A) Snowshoe hares and lynx
- B) Honeyguide birds and humans
- C) Starfish and intertidal mussels
- D) Tiger beetles and ants

2. In Australia, how was the coverage of the invasive prickly pear cactus reduced from millions of hectares to a few thousand?

- A) By applying synthetic chemical herbicides
- B) By introducing the herbivorous moth larva *Cactoblastis cactorum* combined with pathogenic microbes
- C) By flooding pastures with marine saltwater
- D) By conducting annual prescribed forest burns

3. Over what temporal scale do population fluctuations between predators and prey typically occur in nature?

- A) Only over millions of geological years
- B) Highly dynamic fluctuations in abundance ranging from days to decades
- C) Exactly 100 years without variation
- D) Fluctuations occur within minutes during meiotic cell division

4. What general ecological impact do predators, parasites, and pathogens exert on prey and host populations?

- A) They eliminate all genetic variation in host genomes
- B) They influence the distribution, abundance, and structure of prey and host populations
- C) They cause immediate polyploidy in all host species
- D) They force host cells to alter their walls from chitin to silica

Answer Key

- **1. A** — The population cycle of snowshoe hares and their predators is a classic example of dynamic predator-prey interaction.
- **2. B** — Introducing *Cactoblastis cactorum* moth larvae along with plant pathogens drastically reduced prickly pear cactus coverage.
- **3. B** — Populations of predators and prey exhibit dynamic fluctuations in abundance spanning days to decades.
- **4. B** — Exploitative organisms regulate the distribution, population density, and structure of host and prey populations.

Lesson 91: 91-Predator-prey interactions

1. According to the Lotka-Volterra mathematical models, what can produce population cycles without any influence from outside forces such as weather?

- A) Interspecific competition for light
- B) Exploitative interactions themselves
- C) Random genetic drift in small populations
- D) Continuous abiotic temperature shifts

2. How does living in large groups serve as a type of refuge for prey or host species?

- A) It increases the photosynthetic yield of the prey
- B) It reduces the probability that an individual host or prey will be attacked
- C) It prevents predators from undergoing meiotic division
- D) It completely eliminates the need for primary production

3. Which strategy is described as a defensive tactic used by a wide variety of organisms ranging from rainforest trees to temperate insects?

- A) Ecdysis
- B) Predator satiation
- C) Tagmatization
- D) Conjugation

4. In Kenya, which organism was shown to control snails that act as intermediate hosts for the pathogenic human parasite *Schistosoma*?

- A) Snowshoe hare
- B) Crayfish (*Procambarus clarkii*)
- C) Red fox
- D) Flour beetle

Answer Key

- **1. B** — Lotka-Volterra models show that exploitative interactions alone can generate predator-prey population cycles.
- **2. B** — Living in large groups lowers the chance of an individual prey or host being attacked by a predator.
- **3. B** — Predator satiation acts as a defensive tactic across diverse taxa to protect against predation.
- **4. B** — Research in Kenya demonstrated that the crayfish *Procambarus clarkii* controls snail vectors of *Schistosoma*.

Lesson 92: 92-Features of protists

1. What are the three primary functional groups into which protists are classified?

- A) Bacteria, Archaea, and Eukarya
- B) Protozoans, Algae, and Fungus-like protists
- C) Monera, Fungi, and Metazoa
- D) Ciliates, Flagellates, and Sporozoans

2. Which cellular feature distinguishes protozoans from plant cells and fungi?

- A) Absence of a cell wall
- B) Presence of double-membraned chloroplasts
- C) Possession of chitinous exoskeletons
- D) Multicellular tissue organization

3. How are animal-like protists (protozoans) primarily categorized into subgroups?

- A) By their photosynthetic pigments
- B) By their method of movement
- C) By their geological fossil age
- D) By the presence of peptidoglycan layers

4. Which structures do amoebas use for both movement and capturing food into food vacuoles?

- A) Cilia
- B) Pseudopods
- C) Flagella
- D) Spores

Answer Key

- **1. B** — Protists are divided into three main functional categories: protozoans, algae, and fungus-like protists.
- **2. A** — Protozoans are unicellular eukaryotic consumers that lack cell walls.
- **3. B** — Protozoans are classified into subgroups based on locomotion structures (pseudopods, cilia, flagella, or non-motile parasites).
- **4. B** — Amoebas project pseudopods to move and engulf food particles via phagocytosis into food vacuoles.

Lesson 93: 93-Protozoa

1. Which drug is specifically cited in the handout for treating malaria caused by *Plasmodium*?

- A) Penicillin
- B) Quinine
- C) Hirudin
- D) Saxitoxin

2. What vector transmits *Trypanosoma*, the flagellated protozoan responsible for African Sleeping Sickness?

- A) Anopheles mosquito
- B) Tsetse fly
- C) Deer tick
- D) Red flour beetle

3. What is the primary function of conjugation in *Paramecium*?

- A) Producing asexual daughter cells
- B) Exchanging genetic information to increase diversity
- C) Synthesizing silica shells
- D) Secreting a protective calcium carbonate test

4. How does the ciliate *Vorticella* capture its food?

- A) By projecting pseudopods around prey
- B) By spinning its cilia to create a water vortex
- C) By injecting hemolytic necrotoxins
- D) By absorbing light via C4 photosynthetic enzymes

Answer Key

- **1. B** — Quinine is the medication highlighted for treating malaria caused by the sporozoan *Plasmodium*.
- **2. B** — *Trypanosoma* is a parasitic flagellated protozoan transmitted to humans by the tsetse fly.
- **3. B** — Conjugation is a sexual process in *Paramecium* that exchanges genetic material to generate variation.
- **4. B** — *Vorticella* uses its cilia to generate a water vortex that draws food particles toward its oral region.

Lesson 94: 94-Groups of protists

1. What unique combination of features characterizes the euglenoids (such as *Euglena*)?

- A) Absence of a nucleus and obligate anaerobic respiration
- B) Possession of chlorophyll for photosynthesis alongside a flagellum and eyespot for movement
- C) Silica shells and chitinous setae
- D) Multicellular organization with specialized root tissues

2. What structure in *Euglena* detects light, allowing the organism to move toward light sources?

- A) Contractile vacuole
- B) Eyespot (stigma)
- C) Cytoproct
- D) Trophosome

3. How are plant-like protists broadly categorized based on their primary energy acquisition mode?

- A) Heterotrophic saprobes
- B) Photosynthetic algae containing chlorophyll
- C) Obligate chemosynthetic autotrophs
- D) Parasitic spore-formers

4. What carbohydrate storage material is uniquely present in euglenoids?

- A) Peptidoglycan
- B) Paramylon bodies
- C) Chitin
- D) Cellulose

Answer Key

- **1. B** — Euglenoids combine plant-like photosynthetic chlorophyll with animal-like flagellar motility and a light-sensing eyespot.
- **2. B** — The eyespot (stigma) in *Euglena* senses light direction to orient movement toward light.
- **3. B** — Plant-like protists are algae that acquire energy through chlorophyll-based photosynthesis.
- **4. B** — Euglenoids store excess food energy in the form of paramylon bodies.

Lesson 95: 95-Origins and Importance of Protists

1. How are fungus-like protists primarily classified?

- A) By their mode of locomotion
- B) By how they reproduce
- C) By the thickness of their calcareous shell
- D) By their body symmetry plan

2. Which agricultural disaster caused by water molds resulted in two million deaths in Ireland and driven emigration to the United States?

- A) The Bengal Rice Blight
- B) The Irish Potato Famine
- C) The Carboniferous Rainforest Collapse
- D) The Great Dust Bowl

3. What ecological role makes green algae protists essential to aquatic biomes?

- A) Acting as primary producers that serve as oxygen and food sources in plankton
- B) Digesting petroleum spills in deep sub-surface aquifers
- C) Fixing atmospheric nitrogen into soil nitrates
- D) Forming coral reef exoskeletons

4. On what substrate do fungus-like water molds and mildews typically feed?

- A) Living vertebrate muscle tissue
- B) Dead organic material
- C) Pure mineral basalt rocks
- D) Atmospheric methane gas

Answer Key

- **1. B** — Fungus-like protists are classified based on their reproductive methods.
- **2. B** — Water molds caused the Irish Potato Famine, leading to two million fatalities and widespread emigration.
- **3. A** — Green algae protists produce oxygen and form the foundation of aquatic food webs as phytoplankton.
- **4. B** — Fungus-like protists are saprobes that live on and decompose dead organic matter.

Lesson 96: 96-Food Webs

1. What does a food web summarize in an ecological community?

- A) The total rate of solar energy absorption
- B) The feeding relations in a community
- C) The geographic distribution of biomes
- D) The rate of meiotic gene recombination

2. Where was the earliest research on food webs concentrated?

- A) Deep ocean hydrothermal vents
- B) Simplified communities in areas such as Arctic islands
- C) Tropical rainforest canopy layers
- D) Agricultural desert oases

3. What structural effect can introduced exotic predators have on natural food webs?

- A) They increase native species diversity by 50%
- B) They can collapse and simplify the structure of food webs
- C) They eliminate all heterotrophs from the biome
- D) They double the rate of soil nitrogen fixation

4. Which introduced fish species is cited as having a tangled impact on the native fish community of Lake Victoria?

- A) Crayfish (**Procambarus clarkii**)
- B) Nile perch
- C) Asian carp
- D) Red fox

Answer Key

- **1. B** — A food web summarizes the feeding relationships among species in a community.
- **2. B** — Early food web studies focused on simplified community structures in Arctic islands.

- **3. B** — Exotic predators introduced into ecosystems can collapse and simplify food web structures.
- **4. B** — The introduction of the Nile perch impacted the native fish community structure in Lake Victoria.

Lesson 97: 97 - Food web and structure of communities

1. How did Robert Paine describe the ecological role of keystone predators in intertidal communities?

- A) They always possess the highest total biomass in an ecosystem
- B) Their feeding activities control community structure and increase diversity by preventing competitive exclusion
- C) They eliminate all primary producers in aquatic food webs
- D) They function exclusively as saprophytic decomposers

2. How long have Chinese farmers utilized ants as keystone predators to control pests in citrus orchards?

- A) Over 50 years
- B) Over 200 years
- C) Over 1,700 years
- D) Over 5,000 years

3. According to Jane Lubchenco (1978), which factors determine how consumers influence community structure?

- A) Soil pH, altitude, and ground color
- B) Consumer feeding preferences, local population density, and relative competitive abilities of prey
- C) Total annual rainfall and wind velocity
- D) Rate of meiotic crossing over in prey genomes

4. What happens to community species diversity when a keystone predator like the starfish (*Pisaster*) is experimentally removed?

- A) Diversity increases significantly as prey species multiply
- B) Diversity decreases because a single dominant competitor excludes other species
- C) Diversity remains completely unchanged
- D) All autotrophs in the intertidal zone go extinct

Answer Key

- **1. B** — Keystone predators maintain species diversity by consuming dominant competitors, preventing competitive exclusion.
- **2. C** — Chinese farmers have used ants as keystone predators in citrus orchards for over 1,700 years.
- **3. B** — Consumer influence depends on feeding preferences, population density, and relative competitive abilities of prey.
- **4. B** — Removing a keystone predator allows a dominant competitor to monopolize resources, lowering overall diversity.

Lesson 98: 98-Foundation and keystone species

1. What defines a foundation species in an ecological community?

- A) A rare species with low biomass that acts as a top predator
- B) A species that plays a unique, essential role in creating and defining a community, often by modifying the environment
- C) An invasive weed introduced from another continent
- D) A microscopic prokaryote lacking a cell envelope

2. How do foundation species typically differ from keystone species regarding biomass and structural role?

- A) Foundation species always have lower biomass than keystone species
- B) Foundation species usually have high biomass and structure the environment, whereas keystone species exert strong effects despite low biomass
- C) Both foundation and keystone species have zero biomass
- D) Keystone species form the structural framework of coral reefs

3. In some ecological literature, how are foundation species classified in relation to keystone species?

- A) As obligate parasites of keystone species
- B) As a subcategory of keystone species
- C) As an extinct ancestral outgroup
- D) As an abiotic chemical factor

4. Which of the following is a classic example of a foundation species?

- A) Snowshoe hare
- B) Coral species forming reef frameworks
- C) Tsetse fly
- D) *Escherichia coli*

Answer Key

- **1. B** — Foundation species shape community structure by physically creating habitat and defining the environment.
- **2. B** — Foundation species generally have high biomass and structure the habitat, while keystone species exert disproportionate effects relative to low biomass.
- **3. B** — Some sources view foundation species as a specialized subcategory of keystone species.
- **4. B** — Corals are classic foundation species whose calcareous exoskeletons form the physical structure of reef communities.

Lesson 99: 99-From gene product to gene

1. What can serve as the initial entry point for gene discovery when no genomic database exists for a study organism?

- A) Total atmospheric nitrogen concentration
- B) The primary structure of a gene product (protein)
- C) Physical length of the organism's habitat
- D) Fossilized shell of an extinct outgroup

2. Which proteins are particularly suited as starting points for working backwards to identify their encoding genes?

- A) Structural lipids forming plasma membranes

- B) Proteins that can be isolated easily via a marker or bioassay, or are highly induced by experimental treatment
- C) Non-coding intron transcripts
- D) Synthetic carbohydrates synthesized without DNA templates

3. Once an amino acid sequence is determined, what can be designed to isolate the gene from a cDNA library or via PCR?

- A) Synthetic lipid bilayers
- B) Degenerate oligonucleotide probes or primers
- C) Gas chromatography columns
- D) Restriction enzymes for chitin

4. What analytical technique is used to determine peptide sequences from proteolytic digests for gene discovery?

- A) Repeat photography
- B) Mass spectrometry
- C) Satellite remote sensing
- D) Northern blotting

Answer Key

- **1. B** — The primary amino acid structure of an isolated protein can serve as the entry point for discovering its gene.
- **2. B** — Easily isolated or highly induced proteins provide accessible starting material for reverse gene discovery.
- **3. B** — Degenerate oligonucleotide primers or probes are designed based on amino acid sequences to isolate corresponding DNA.
- **4. B** — Mass spectrometry identifies peptide sequences from protein digests, enabling reverse gene isolation.

Lesson 100: 100-Colinearity of Gene and Protein

1. What does the "colinearity of gene and protein" principle state?

- A) DNA and proteins are physically joined in a continuous ring of life
- B) The linear sequence of nucleotides in a gene directly corresponds to the linear sequence of amino acids in a protein
- C) Proteins are transcribed directly into DNA without RNA intermediates
- D) All amino acids are encoded by identical nucleotide triplets

2. How is a single amino acid encoded in the nonoverlapping genetic code?

- A) By a single nucleotide base
- B) By a codon consisting of three nucleotide bases (triplet)
- C) By a full transfer RNA loop
- D) By an intron sequence

3. What does it mean that the genetic code is "degenerate"?

- A) The code degrades over time due to high mutation rates
- B) More than one codon can code for the same amino acid
- C) Codons overlap during ribosomal translation

D) Stop codons can encode functional structural proteins

4. Which codon serves as the universal start codon to initiate translation from a fixed starting point?

- A) UAA
- B) UAG
- C) UGA
- D) AUG

Answer Key

- **1. B** — Colinearity means the linear nucleotide sequence of a gene dictates the linear amino acid sequence of its protein.
- **2. B** — A codon consisting of three bases (a triplet) encodes a specific amino acid.
- **3. B** — Degeneracy refers to the property where multiple different codons can encode a single amino acid.
- **4. D** — AUG is the universal start codon that defines the reading frame for translation.

End of Quiz

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