AP Biology
AP Exam Study Guide

Big Idea 1: The process of evolution drives the diversity and unity of life.

1) What is the definition of "evolution"?
2) Describe Darwin's Theory of Natural Selection.
3) How is evolutionary fitness measured?
4) Why do genetic variation and mutation play roles in natural selection as it relates to environmental pressure?
5) How can environments affect evolutionary rate and direction?
6) What is an adaptation?
7) Why do chance and random events influence the evolutionary process in small populations more than large populations?
8) List and DESCRIBE the conditions necessary for a population to be in Hardy-Weinberg equilibrium. What does it mean if the population is NOT in Hardy-Weinberg equilibrium?
9) A population of has 35,746 individuals that show the recessive phenotype. Assuming this population is in Hardy-Weinberg equilibrium, determine p, q, p^2, 2pq, & q^2 for the next generation of this population.
10) When a population encounters a selective pressure, where is it usually coming from? Describe why the peppered moth and the changes in flowering time around the world are illustrative examples of this.
11) How are phenotypic variations directed?
12) Describe how each of the following phenotypic variations increase or decrease fitness of the organism and the population:
    - Sickle-cell anemia
    - Peppered moth
    - DDT resistance in insects
13) Describe how each of the following are examples of how humans impact variation in other species:
    - Artificial selection
    - Loss of genetic diversity within a crop species
    - Overuse of antibiotics
14) Describe genetic drift. Why does it affect smaller populations more than larger populations?
15) Explain why a reduction in genetic variation within a population can increase the differences between populations of the same species over time.
16) Describe the meaning behind the fact that evolution is a scientific theory.
17) Explain how each of the following examples add to our understanding of evolution:
    - Fossil dating
    - Morphological homologies and vestigial structures
    - Biochemical and genetic similarities
18) Explain how the analysis of genetic sequence data sets and phylogenetic trees can be used to illustrate and support evolutionary concepts.
19) Describe how each of the following examples support the relatedness of all domains of life:
    - Central dogma
    - Genetic code
    - Metabolic pathways
20) How do each of the following pieces of structural evidence support the relatedness of all eukaryotes:
    - Cytoskeleton
    - Membrane-bound organelles
    - Linear chromosomes
    - Endomembrane systems (including the nuclear envelope)
21) Produce a cladogram that includes the following characteristics and provides a representative animal for each branch:
    - # of heart chambers in animals
    - Opposable thumbs
    - Absence of legs in mammals

22) How do phylogenetic trees and cladograms illustrate speciation?
23) What is the difference between the phylogenetic trees of Darwin and modern-day phylogenetic trees?
24) Describe the dynamic nature of phylogenetic trees.
25) Explain how varying speciation rates can be correlated to adaptive radiation.
26) Describe how each of the following are illustrative examples of how species extinction rates can be affected by ecological stress:
    - Five major extinctions
    - Human impacts on ecosystems
27) Explain how gene flow is disrupted by the major forms of pre- and post-zygotic isolation. How is this related to reproductive isolation?
28) Describe the time scale necessary for evolution to occur.
29) Provide and describe a non-human example of how evolution has occurred in the 5 major eukaryotic kingdoms, as well as in prokaryotes.
30) Describe how each of the following illustrative examples support the idea that evolution continues to occur:
    - Chemical resistance (antibiotics, pesticides, herbicides, or chemotherapy)
    - Emergent diseases
    - Observed directional phenotypic change in a population
    - A eukaryotic example that describes evolution of a structure or process such as heart chambers, limbs, the brain and the immune system
31) Explain the supporting scientific evidence that backs the following hypotheses regarding the natural origin of life on Earth:
    - Synthesis of organic molecules from inorganic precursors
    - Synthesis of the monomers of the four major organic macromolecules
    - Synthesis of these monomers into polymers, including those that store and transmit information
    - "Organic soup model" vs "solid reactive surfaces model" for complex reactions
    - RNA World hypothesis
32) Describe the geologic evidence that provides a plausible range of dates when the origin of life could have occurred.
33) Describe the molecular and genetic evidence from extant and extinct organisms that indicates all organisms on Earth share a common ancestral origin of life.

<u>Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.</u>

34) Describe each of the following examples of the highly-ordered systems of life:
    - Order is maintained by constant free energy input into the system
    - Loss of order or free energy flow results in death
    - Increased disorder and entropy are offset by biological processes that maintain or increase order
35) Describe how each of the following examples allow living systems to maintain dynamic homeostasis without violating the second law of thermodynamics:
    - Coupling $-\Delta G$ processes with $+\Delta G$ processes
    - Energy input > free energy lost
    - Coupling exergonic reactions with endergonic reactions
36) Describe how each of the following examples are sequential, energy-related pathways in biological systems and may be entered at multiple points in the pathway:
    - Krebs cycle
    - Calvin cycle
    - Glycolysis
    - Fermentation
37) What is the definition of "free energy" in a biological system?
38) Explain why the following are examples of how organisms use various strategies to regulate body temperature and metabolism:
    - Endothermy
    - Elevated floral temperatures
    - Ectothermy

39) How must free-energy-needs be adjusted during times of reproduction and child-rearing?
40) Explain how the following reproductive strategies are ways to adjust to varying energy availability:
    - Seasonal reproduction in animals and plants
    - Life-history strategy (i.e., biennal plants, reproductive diapause)
41) Describe the relationship between metabolic rate per unit body mass and the size of multicellular organisms.
42) What happens when acquired free energy exceeds free energy expenditures? What happens when free energy expenditures exceed the acquired free energy?
43) How would changes to free energy availability result in changes to a population?
44) Explain how the following examples would result in changes to free energy availability. In each of these examples describe what would happen to the ecosystem if these things happened:
    - Changes in the producer level
    - Changes in energy resource levels (such as sunlight)
45) Describe how each of the following are examples of autotrophs capturing free energy from physical/inorganic sources in the environment:
    - Photosynthetic organisms
    - Chemosynthetic organisms (in the absence of oxygen)
46) Explain the process by which heterotrophs capture free energy present in carbon compounds (both aerobically and anaerobically), which are produced by other organisms.
47) Describe the process by which the following molecules act as electron acceptors:
    - $NADP^+$
    - O_2
48) Describe the processes carried out by the light-dependent reactions, including their reactants and products. What are the products used for? Your answer should include a discussion of the following terms:
    - ADP/ATP
    - ATP synthase
    - Calvin Cycle
    - Carbohydrates
    - Carbon dioxide
    - Chlorophylls
    - Chloroplast
    - Electrochemical gradient
    - Electron Transport Chain (ETC)
    - Electrons
    - Free energy
    - Hydrogen ions
    - Inorganic phosphate
    - NADPH
    - Photosynthesis
    - Photosystems I & II
    - Proton-motive force
    - Stroma
    - Sunlight
    - Thylakoids
49) Explain the evolution of photosynthesis in prokaryotic organisms. How did this lead to the evolution of eukaryotes and eukaryotic photosynthesis?
50) Describe the processes carried out by cellular respiration, including their reactants and products. You do not have to go into detail about ETC (that is the next question). Your answer should include a discussion of the following terms:
    - ATP/ADP
    - Carbon dioxide
    - Coenzymes
    - Electron transport chain
    - $FADH_2$
    - Free electrons
    - Free energy
    - Glucose
    - Glycolysis
    - Inorganic phosphate
    - Krebs Cycle
    - Mitochondrion
    - NADH
    - Oxidation
    - Oxidative phosphorylation
    - Pyruvate
    - Reduction
    - Substrate-level phosphorylation

51) Describe the processes carried out by the electron transport chain, including their reactants and products. Your answer should include a discussion of the following terms:
- ATP/ADP
- Cellular respiration
- Chemiosmosis
- Chloroplasts
- $FADH_2$
- Inner mitochondrial membrane
- Inorganic phosphate
- Mitochondria
- NADH
- $NADP^+$
- O_2
- Oxidative phosphorylation
- Photosynthesis
- Plasma membrane
- Prokaryotes
- Proton gradient
- Proton gradient
- Thermoregulation
- Thylakoid membrane

52) How does the conversion of adenosine triphosphate to adenosine diphosphate result in the release of free energy?

53) Summarize the steps involved with the biotic and abiotic carbon cycles. Be sure to include the molecules being made at each step.

54) Summarize the steps involved with the nitrogen cycle. Be sure to include the organisms needed to perform each step, as well as the molecules made at each step.

55) Why do living organisms need each of the following elements:
- Nitrogen
- Carbon
- Hydrogen
- Oxygen
- Phosphorus
- Sulfur

56) Discuss why the following properties of water are necessary for living systems:
- Cohesion
- Adhesion
- High specific heat capacity
- Universal solvent
- Heat of vaporization
- Heat of fusion
- Thermal conductivity

57) All of the properties of water that were discussed above are due to which properties of water?

58) Describe how surface-area-to-volume ratio affects a biological system's ability to obtain necessary resources or eliminate waste products. How does this affect cell size?

59) Explain how each of the following illustrative examples are solutions to the surface-area-to-volume ratio problem:
- Root hairs
- Cells of the alveoli
- Cells of the villi
- Microvilli

60) Explain why smaller cells have more favorable surface-area-to-volume ratios. Provide a quantitative example of this.

61) How did the evolution of cell membranes lead to the origin of life?

62) Describe the concept of selective-permeability, as described by the fluid mosaic model of cell membranes.

63) Cell membranes consist of which FIVE biochemical molecules? What are the functions of each?

64) Explain how phospholipids give cell membranes both hydrophilic and hydrophobic properties.

65) How does the polarity of a protein's side groups help it remain embedded in the cell membrane?

66) Based on the cell membrane's selectively permeable nature, what kinds of molecules may pass freely through it? How do other molecules pass through?

67) Describe how cell walls differ from cell membranes. Give examples of three different types of organisms that have cell walls, and describe how they differ from each other.

68) Explain the method by which molecules are transported actively and passively across the cell membrane. Be sure to explain the role of metabolic energy and concentration gradients in your description.

69) Compare and contrast simple diffusion vs facilitated diffusion, providing illustrative examples of each.

70) What does it mean for a cellular environment to be hyper-, hypo-, and isotonic? How does this help determine the water potential of a system?

71) Why are membranes required for active transport to take place? Provide an illustrative example of this.

72) Compare and contrast the concepts of endocytosis and exocytosis. Be sure to provide a comprehensive explanation that includes the role of specific organelles during each process.

73) How do internal cellular membranes facilitate cellular processes?

74) Describe the intracellular metabolic processes and specific enzymatic reactions associated with each of the following membranes/membrane-bound organelles:
    - Chloroplasts
    - Endoplasmic reticulum
    - Golgi
    - Mitochondria
    - Nuclear envelope
    - Ribosomes
    - Vacuoles
    - Vesicles
75) How do the membranes and membrane-bound organelles differ between the three domains of life?
76) Describe the concept of negative feedback in terms of dynamic homeostasis and the maintenance of a physiological set point.
77) Explain why each of the following are illustrative examples of negative feedback:
    - Operons in gene regulation
    - Temperature regulation in animals
    - Plant responses to water limitations
78) Describe the concept of positive feedback in terms of response amplification and the introduction of a stimulus. How does this differ from negative feedback in terms of the set point?
79) Explain why each of the following are illustrative examples of positive feedback:
    - Lactation in mammals
    - Onset of labor in childbirth
    - Ripening of fruit
80) Explain why each of the following disorders are the result of a deleterious alteration of feedback mechanisms:
    - Diabetes mellitus in response to decreased insulin
    - Dehydration in response to decreased antidiuretic hormone (ADH)
    - Graves' disease (hyperthyroidism)
    - Blood clotting
81) Explain why each of the following are illustrative examples of how organisms respond to changes in the environment. Be sure to include whether these changes are behavioral or physiological:
    - Photoperiodism and phototropism in plants
    - Hibernation and migration in animals
    - Taxis and kinesis in animals
    - Chemotaxis in bacteria; sexual reproduction in fungi
    - Nocturnal and diurnal activity; circadian rhythms
    - Shivering and sweating in humans
82) How does each of the following illustrative examples affect cellular activities? Provide whether each of these is biotic or abiotic:
    - Cell density
    - Biofilms
    - Temperature
    - Water availability
    - Sunlight
83) How does each of the following illustrative examples affect the activity of organisms? Provide whether each of these is biotic or abiotic:
    - Symbiosis (mutualism, commensalism, parasitism)
    - Predator-prey relationships
    - Water and nutrient availability, temperature, salinity, pH
84) How does each of the following illustrative examples affect the stability of populations, communities, and/or ecosystems? Provide whether each of these is biotic or abiotic:
    - Water and nutrient availability
    - Availability of nesting materials and sites
    - Food chains and food webs
    - Species diversity
    - Population density
    - Algal blooms

85) Explain how the continuity of homeostatic mechanisms reflects common ancestry. How do different environmental conditions affect these mechanisms?

86) How is the concept of common ancestry supported by each of the following illustrative examples of homeostatic control mechanisms?
- Excretory systems in flatworms, earthworms, and vertebrates
- Osmoregulation in bacteria, fish, and protists
- Osmoregulation in aquatic and terrestrial plants
- Circulatory systems in fish, amphibians, and mammals
- Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms)

87) Describe the following mechanisms for obtaining nutrients and eliminating wastes:
- Gas exchange in water and terrestrial plants
- Digestive mechanisms in animals (such as food vacuoles, gastrovascular cavities, one-way digestive systems, etc.)
- Respiratory systems of aquatic and terrestrial animals
- Nitrogenous waste production and elimination in aquatic and terrestrial animals

88) How do each of the following illustrative examples provide evidence that disruptions at the molecular and cellular levels affect the health of an organism:
- Physiological responses to toxic substances
- Dehydration
- Immunological responses to pathogens, toxins, and allergens

89) How do each of the following illustrative examples provide evidence that disruptions to ecosystems impact the dynamic homeostasis of the ecosystem:
- Invasive and/or eruptive species
- Human impact
- Hurricanes, floods, earthquakes, volcanoes, and fires
- Water limitation
- Salination

90) Provide evidence for each of the following immune responses:
- Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses
- Plant defenses against pathogens include molecular recognition systems with systemic responses (e.g., compartmentalization)
- Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens

91) Explain each of the following mammalian immune responses that are specific towards a pathogen:
- Cell-mediated vs. humoral
- Role of cytotoxic T-cells
- Role of B-cells and antibodies
- Antigens vs antibodies
- Antibody specificity
- Initial pathogen exposure vs subsequent pathogen exposures (rate of response, role of memory cells, etc.)

92) How does the expression of genes for tissue-specific proteins result in observable cell differentiation?

93) Elaborate on the following concepts that address how the induction of transcription factors during development results in sequential gene expression:
- Homeotic genes
- Embryonic induction
- Temperature and water availability during seed germination
- Genetic mutations and abnormal development
- Genetic transplantation experiments linking gene expression and normal development
- Genetic regulation of development and cellular control using microRNAs

94) Explain how each of the following illustrative examples provide evidence of the importance of apoptosis in normal development and differentiation:
- Morphogenesis of fingers and toes
- Immune function
- *C. elegans* development
- Flower development

95) How do the following plant physiological events involve interactions between environmental stimuli and internal molecular signals:
- Phototropism
- Photoperiodism

96) How do the following animal physiological events involve interactions between internal/external signals and environmental cues:
- Circadian rhythms
- Diurnal/nocturnal and sleep/wake cycles
- Seasonal responses (e.g., hibernation, estivation, migration, etc.)
- Release and reaction to pheromones
- Visual displays in the reproductive cycle
- Jet lag

97) Contrast innate vs learned behaviors, and use them both to explain how individuals can act on information and communicate it with others.

98) How are each of the following examples responses to information and communication? How can each be correlated to natural selection?
- Photoperiodism (changes in light source AND changes in night length)
- Animal behavior (with a discussion of the following):
  i. Hibernation
  ii. Estivation
  iii. Migration
  iv. Courtship

99) How do each of the following cooperative behaviors contribute to the survival of multiple populations:
- Availability of resources leading to fruiting body formation (in fungi and some bacteria)
- Niche and resource partitioning
- Mutualistic relationships (lichens; bacteria in the digestive tracts of animals; mycorrhizae)
- Biology of pollination

<u>Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes.</u>

100) Describe the role of nucleic acids as a way to store genetic information and to pass information on to subsequent generations?

101) Compare and contrast the chromosomes of noneukaryotic and eukaryotic organisms.

102) What is a plasmid? In which organisms can they be found?

103) Explain how the following scientists performed experiments providing evidence that DNA is the carrier of genetic information:
- Watson & Crick
- Wilkins & Franklin
- Avery/MacLeod/McCarty
- Hershey & Chase

104) Explain how DNA replication ensures the continuity of hereditary information, using the following terms:
- Bidirectional
- Complimentary strand
- DNA helicase
- DNA ligase
- DNA polymerase
- Enzymes
- Lagging strand
- Leading strand
- Okazaki fragments
- Semiconservative
- Semidiscontinuous
- Template strand

105) Describe how retroviruses violate the Central Dogma.

106) Compare and contrast DNA & RNA:
- Nucleotide structure
- Sugar
- # of strands
- Antiparallel strands
- Nitrogenous bases (purines vs pyrimidines)
- Nitrogenous base pairing

107) Describe the role of the three types of RNA.

108) What is the role of RNAi in terms of gene regulation?

109) What is the role of RNA polymerase and topoisomerases during protein synthesis?
110) In which direction do polymerases move down the template strand? In which direction do they build the new strand?
111) Describe the following enzyme-regulated modifications that are used to regulate gene expression at the mRNA level:
- Addition of a poly-A tail
- Addition of a GTP cap
- Excision of introns

112) Compare and contrast the translation of mRNA on a free vs attached ribosome.
113) Describe the processes of transcription and translation. Make sure your explanation includes a discussion of the following terms:
- amino acid
- A-site
- codon
- Elongation
- genetic code
- Initiation
- large ribosomal subunit
- mRNA
- nucleotides
- peptide bond
- peptide chain
- P-site
- ribosome
- rRNA
- small ribosomal subunit
- start codon
- stop codon
- Termination
- triplets
- tRNA

114) Explain how phenotypes can be determined by the following activities:
- Enzymatic activities
- Transport proteins
- Protein synthesis
- Protein degradation

115) Describe how the following genetic engineering techniques can manipulate the heritable information of nucleic acids:
- Electrophoresis
- Plasmid-based transformation
- Restriction enzyme analysis of DNA
- Polymerase Chain Reaction (PCR)

116) Describe how genetic engineering can be used to acquire the following products:
- Genetically-modified foods
- Transgenic animals
- Cloned animals
- Pharmaceuticals, such as human insulin or factor X

117) Describe the internal control of the cell cycle. Your answer should include a discussion of the following terms:
- cyclin-dependent kinases
- cyclins
- growth phase
- interphase
- mitosis
- mitosis-promoting factor (MPF)
- platelet-derived-growth-factor (PDGF)
- synthesis phase

118) How does a cell specialize its function? Do these cells continue to go through the cell cycle?
119) Describe the process of mitosis, ensuring you address the following concepts:
- Placement in the cell cycle
- Chromosome number of parent & daughter cells
- Role in growth, repair, and reproduction
- Observable structural features during the process
- Correct order of the processes
- Asexual reproduction

120) How do the processes of meiosis and fertilization increase genetic diversity in sexually-reproducing organisms?
121) Describe the process of meiosis, ensuring you address the following concepts:
- Chromosome number of parent & daughter cells
- Homologous chromosomes
- Crossing over
- Gametogenesis

122) How can the rules of probability be applied to analyze passage of single gene traits from parent to offspring?

123) How do segregation and independent assortment result in increased genetic variation? Be sure to include a discussion of the following concepts:
- Linked vs un-linked genes
- Correlating recombination rate with gene distance

124) Given the parental genotypes/phenotypes and/or the offspring genotypes/phenotypes, how would you predict the pattern of inheritance for a gene in each of the following instances:
- Monohybrid
- Dihybrid
- Sex-linked
- Linked genes

125) Describe the specific mutations that cause the following genetic diseases:
- Huntington's disease
- Klinefelter's syndrome
- Sickle-cell anemia
- Tay-Sachs disease
- Trisomy 21/Down syndrome
- X-linked color blindness

126) Discuss the ethical, social, and medical issues surrounding human genetic disorders. Be sure you include a discussion of reproductive issues, as well as civic issues such as the ownership of genetic information, privacy, historical contexts, etc.

127) Describe the concept of using a Chi-Squared Goodness of Fit Test to determine whether a predicted pattern of inheritance matches the observed data (i.e., EXPLAIN the formula and concepts behind the test).

128) Why are most sex-linked chromosomes found on the X-chromosome of humans? Use this question to compare and contrast the X and Y chromosomes in humans.

129) Contrast the genotype of males and females. How does this explain why males are more likely to inherit a sex-linked trait?

130) Give examples of sex-limited traits (traits whose expression is specifically dependent on gender).

131) Provide the two major examples of non-nuclear inheritance. In animals, how is non-nuclear inheritance determined?

132) Give examples of regulatory RNA molecules that are involved with gene expression.

133) What are the three types of regulatory sequences we discussed in class, and how do they interact with regulatory proteins to control transcription?

134) What is a regulatory gene? Provide an example of a regulatory gene product.

135) Describe the positive and negative control mechanisms that regulate gene expression in bacteria and viruses. Your description should include a discussion of the following terms:
- Continual expression
- Inducer
- Inhibition
- Regulatory proteins
- Regulatory sequences
- Repressor
- Transcription

136) Explain the gene control mechanism of eukaryotes. Your explanation should include a discussion of the following terms:
- Activators
- Enhancer
- Promoter
- Regulatory proteins
- Regulatory sequences
- Repressors
- Transcription factors

137) How can gene regulation be associated with phenotypic differences between genotypically-similar organisms?

138) Provide an explanation of each of the following examples of signal transmission within and between cells, which can mediate gene expression:
- The role of cytokines in cell replication and division
- Mating pheromones in yeast
- The use of cAMP to regulate metabolic processes in bacteria
- Expression of the SRY gene in animals
- The role of ethylene in angiosperms
- Gibberellins and seed germination

139) Provide an explanation of each of the following examples of signal transmission within and between cells, which can mediate gene function:
- Mating pheromones in yeast
- The role of morphogens in cell differentiation and development
- Cancer and the role of p53
- HOX genes

140) Explain how DNA mutations can be either positive, negative, or neutral based on their effect on the resulting nucleic acid and/or polypeptide.

141) Explain the different sources of DNA mutations. Can these mutations be predicted?

142) How do mutations correlate with genetic variation and environmental pressure?

143) Describe how errors in mitosis or meiosis can result in phenotypic changes. Your description should include a discussion of the following concepts:
- Polyploidy
- Polyploid sterility
- Increased polyploid vigor (in plants)
- Developmental limitations caused by aneuploidy

144) What must be true of a genetic mutation in order for it to be subject to natural selection?

145) Explain how each of the following illustrative examples provides evidence that selection results in evolutionary change:
- Antibiotic-resistant mutations
- Pesticide-resistant mutations
- Sickle-cell disorder and heterozygote advantage

146) How does the imperfect nature of DNA replication and repair increase genetic variation? How can this be associated with mutation rate?

147) Describe the following prokaryote methods of horizontal gene transfer:
- Transformation
- Transduction
- Conjugation
- Transposition (also in eukaryotes)

148) Why are reproductive processes that increase genetic variation evolutionarily conserved?

149) Describe how viral replication differs from other reproductive strategies and can generate genetic variation. Your description should involve a discussion of the following concepts:
- Rapid viral evolution and acquisition of new phenotypes
- Component-assembly model
- Simultaneous assembly of progeny
- Mutation of genetic information via host pathways
- Increased rates of mutations in retroviruses
- Combining/recombining information between related viruses infecting the same host cell
- HIV as a model for these processes

150) Associate the concepts of transduction and transposons viral transmission of genetic information.

151) Compare and contrast the lytic and lysogenic modes of viral replication.

152) Why would correct/appropriate signal transduction processes generally be under strong selective pressure?

153) Explain why each of the following are examples of how, in single-celled organisms, signal-transduction pathways influence how the cell responds to its environment:
- Quorum sensing
- Pheromones
- Cell movement

154) Explain why each of the following are examples of how, in multicellular organisms, signal-transduction pathways coordinate the activities within individual cells that support the function of the organism as a whole:
- Epinephrine stimulation of glycogen breakdown in mammals
- Temperature determination of sex in some vertebrates
- DNA repair mechanisms

155) Describe the following illustrative examples of how cells communicate by cell-to-cell contact:
- APCs, helper T-cells, and killer T-cells
- Plasmodesmata between plant cells

156) Describe the following illustrative examples of how cells communicate over short distances by using local regulators that target cells in the vicinity of the emitting cell:
- Neurotransmitters
- Plant immune response
- Quorum sensing in bacteria
- Morphogens in embryonic development

157) What types of signals are used to travel long distances to target cells of another cell type?

158) Explain how each of the following travel long distances through the blood from an origin to a destination:
- Insulin
- HGH
- Thyroid hormones
- Testosterone
- Estrogen

159) Signal transduction begins with the recognition of a chemical messenger called a what? What recognizes this chemical messenger? Is this process general or specific?

160) Describe how each of the following receptor proteins recognizes a signal molecule, causing a structure change, which initiates transduction:
- G-protein linked receptors
- Ligand-gated ion channels
- Receptor tyrosine kinases

161) How is signal transduction converted into a cellular response?

162) How do signaling cascades relay signals from receptors to cell targets? How can this amplify an incoming signal?

163) Why are second messengers often essential to the function of a signaling cascade?

164) Describe how each of the following could be used to help continue the signal of a water-soluble signaling molecule:
- Ligand-gated ion channels
- Cyclic GMP/AMP
- Calcium ions
- Inositol triphosphate (IP_3)

165) Explain how protein modifications may be a part of a signal-transduction pathway.

166) Explain how phosphorylation cascades involving kinases and phosphatases work.

167) Describe how each of the following illustrative examples can be described by the term preceding it:
- Deleterious: diabetes, heart disease, neurological disease, autoimmune disease, cancer, cholera
- Preventative: neurotoxins, poisons, pesticides
- Prophylactic: hyptertensives, anesthetics, antihistamines, birth control

168) Explain how each of the following are illustrative examples of how organisms exchange information with each other in response to internal changes and external cues, which can change behavior:
- Fight or flight response
- Predator warnings
- Protection of young
- Plant-plant interactions due to herbivory
- Avoidance responses

169) How do each of the following examples evoke behavioral changes in other organisms, possibly resulting in differential reproductive success:
- Herbivory responses
- Territorial marking in mammals
- Coloration in flowers

170) Describe the reasoning behind each of the following signaling behaviors:
- Bee dances
- Bird song
- Territorial marking in mammals
- Herd, flock, and schooling behavior in animals
- Pack behavior in animals
- Predator warning
- Colony and swarming behavior in insects
- Coloration

171) Categorize each of the following behaviors as either innate or learned, and explain how they increase survival and reproductive fitness:
- Parent/offspring interactions
- Migration patterns
- Foraging in bees and other animals
- Courtship and mating behaviors
- Avoidance behavior to electric fences, poisons, or traps

172) How do the following cooperative behaviors tend to increase the survivability of a population:
- Pack behavior in animals
- Herd, flock, and schooling behavior in animals
- Predator warning
- Colony and swarming behavior in insects

173) What is the basic structure of the nervous system? Describe the different parts of this structure. Where do detection, generation, transmission, and integration take place?

174) What is the function of Schwann cells and Nodes of Ranvier?

175) Describe the process of action potential propagation. Your description should include a discussion of the following terms:
- ATP
- depolarization
- ion pumps
- membrane
- polarization
- potassium
- potential
- sodium
- stimulus
- voltage-gated ion channels

176) Describe the function of each of the following neurotransmitters and categorize them as either stimulatory or inhibitory:
- Acetylcholine
- Dopamine
- Epinephrine
- GABA
- Norepinephrine
- Serotonin

177) Describe which region of the brain deals with the following functions:
- Vision
- Hearing
- Muscle movement
- Abstract thought & emotions
- Neuro-hormone production

178) Provide the functions of the following regions of the brain:
- Forebrain (cerebrum)
- Hindbrain (cerebellum)
- Left cerebral hemisphere
- Midbrain (brainstem)
- Right cerebral hemisphere

Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

179) How is biological information encoded in nucleotide monomers?

180) How do the different structures of DNA and RNA account for their different functions?

181) What level of protein structure is determined by amino acid sequence? How does this affect the subsequent levels of protein structure?

182) Are most lipid polar or nonpolar? How does this differ from phospholipids?

183) How are carbohydrates structured?

184) Compare and contrast cellulose, starch, and glycogen.

185) Distinguish between the amino and carboxyl ends of an amino acid. How are amino acids linked together?

186) How does the bonding between carbohydrate subunits determine its secondary structure?

187) How do you determine the two different ends of a nucleic acid? In what direction do replication and transcription enzymes move down a template strand? In what direction are new strands built?

188) Describe the process of dehydration synthesis to attach proteins together. What type of bond is formed during this process?

189) Describe the structure of a ribosome. Be sure to discuss the different types of ribosomal subunits, as well as what makes up each subunit.

190) Describe the SPECIFIC structures and functions of the following membrane-bound organelles:
- Golgi complex
- Lysosomes
- Rough ER
- Smooth ER
- Vacuoles
- Vesicles

191) Provide a detailed description of the structure and function of mitochondria and chloroplasts. Be sure to include a discussion of the role of chlorophyll.
192) How do internal and external cues regulate gene regulation, resulting in differentiation in development?
193) What causes the structural and functional divergence of cells during development?
194) Explain the role of epigenetics in gene expression.
195) Describe how interactions and coordination between the following organs provide essential biological activities:
    - Stomach & small intestines
    - Kidney & bladder
    - Root, stem, & leaf
196) Describe how interactions and coordination between the following systems provide essential biological activities:
    - Respiratory & circulatory
    - Nervous & muscular
    - Plant vascular & leaf
197) How is the structure of a community measured and described?
198) Produce a graphical model that illustrates how the following population/environmental interactions impact the community:
    - Predator/prey relationships
    - Symbiotic relationships
    - Field data
    - Introduction of non-native species
    - Global climate change
199) Produce a graphical representation that illustrates each of the following growth patterns and interactions:
    - Reproduction w/o constraints
    - Population density that exceeds the system's resource availability
    - Reproduction w/ density-dependent and –independent factors imposed
    - Demographic data with respect to age distributions and fecundity
200) How do matter and energy move through a system?
201) How do changes in regional/global climates and in atmospheric composition influence primary productivity?
202) Draw a food web that shows how individuals within the web interact. What is the role of primary producers in the food web?
203) Describe the competition for resources and other factors using the logistic growth model.
204) What are factors that contribute to density-dependent population regulation?
205) How do human populations affect other species? Provide an answer and an example that discusses the impact on both population sizes and habitats.
206) Provide an example and a description of an adaptation that is related to obtaining and using energy and matter in a particular environment.
207) How does a change in a molecular system result in a change in the function of the system?
208) Describe the Lock-and-Key model, as well as the Induced-Fit model of enzymatic action. Make sure your description includes a discussion of active sites and substrates.
209) How do cofactors and coenzymes affect enzyme action? What is the difference between the two?
210) How can other molecules and the environment enhance/inhibit enzyme activity? Be sure to include a discussion of allosteric sites.
211) Describe how the change in an enzyme's function can be interpreted by the rate of a reaction.
212) How do the plasma membrane, cytoplasm, contribute to specialization and functioning in a prokaryotic cell? How do organelles do this in a eukaryotic cell?
213) Describe how the specialization of organs leads to the following functions (not just in humans):
    - Exchange of gases
    - Circulation of fluids
    - Digestion of food
    - Excretion of wastes

214) Describe how interactions among cells of a population of unicellular organisms can be similar to those of multicellular organisms.

215) How do each of the following interactions lead to increased efficiency and utilization of energy and matter:
- Bacterial community in the rumen of animals
- Bacterial community in and around deep sea vents

216) How do the different symbioses affect population dynamics:
- Competition
- Parasitism
- Predation
- Mutualism
- Commensalism

217) Graphically model each of the following relationships:
- Predator/prey
- Epidemiological models
- Invasive species

218) Describe how feedback control systems play a role in the functioning of an ecosystem that has many complex symbiotic relationships.

219) Explain how cooperation and competition can result in a population having different characteristics than the individuals that make up the population.

220) How can each of the following affect species distribution and abundance:
- Species-specific catastrophes
- Environmental catastrophes
- Geological events
- Sudden influx/depletion of abiotic resources
- Increased human activities

221) How do the following examples illustrate the question above:
- Loss of keystone species
- Kudzu
- Dutch elm disease

222) Explain why logging, slash and burn agriculture, urbanization, monocropping, infrastructure development (dams, transmission lines, roads), and global climate change threaten ecosystems and life on earth.

223) How can introduced species exploit a new niche free of predators or competitors (thus exploiting new resources)?

224) Explain how each of the following introduced diseases devastated native species:
- Dutch elm disease
- Potato blight
- Small pox

225) How do each of the following biogeographical changes illustrate how geological and meteorological events can impact ecosystem distribution:
- El Nino
- Continental drift
- Meteor impact on dinosaurs

226) How do each of the following molecular variations provide cells and organisms with a wider range of functions:
- Different types of phospholipids in cell membranes
- Different types of hemoglobin
- MHC proteins
- Chlorophylls
- Molecular diversity of antibodies in response to an antigen

227) How might heterozygotes have an advantageous genotype than homozygotes in response to environmental stresses?

228) How is the “antifreeze gene” in arctic fish an illustrative example of a beneficial gene duplication?

229) Explain how each of the following are examples of how the environment can influence the expression of traits:
- Height & weight in humans
- Flower color based on soil pH
- Seasonal fur color in arctic animals
- Sex determination in reptiles
- Density of plant hairs as a function of herbivory
- Effect of adding lactose to a Lac+ bacterial culture
- Effect of increased UV on melanin production in animals
- Presence of the opposite mating type on pheromone production in yeast and other fungi

230) Explain how each of the following examples are illustrative of how adaptations to the local environment can reflect a flexible response of a genome:
- Darker fur in cooler regions of the body in certain mammal species
- Alterations in timing of flowering due to climate changes

231) Describe how each of the following examples are illustrative how low genetic diversity corresponds to a high risk of extinction for a population:
- California condors
- Black-footed ferrets
- Prairie chickens
- Potato blight causing the potato famine
- Corn rust on agricultural crops
- Tasmanian devils and infectious cancer

232) Explain how genetic diversity allows individuals of a population to respond differently to the same environmental changes, using the following illustrative examples:
- Stampede behavior
- Disease outbreaks

233) Draw a graphical model of allelic variation in a population during the Hardy-Weinberg equation.

234) Explain why ecosystems with fewer component parts and with little diversity tend to be less resilient to changes in the environment.

235) Explain how keystone species, produces, and essential abiotic/biotic factors contribute to maintaining the diversity of an ecosystem.