The Research-Driven Solution to Raise the Quality of High School Core Courses

QualityCore®

Biology

ACT Course Standards

ACT®

QualityCore®

ACT Course Standards
Biology

A set of empirically derived course standards is the heart of each QualityCore® science course. The ACT Course Standards represent a solid evidence-based foundation in science. They were developed from an intensive study of high-performing high schools with significant minority and low-income enrollments that produced many graduates who met or exceeded ACT College Readiness Benchmark Scores (See http://www.act.org/path/policy/reports/success.html).

This document contains a list of ACT Course Standards for a rigorous Biology course—what students should know and be able to do in the course—and a worksheet teachers can use to compare their course content to these standards. The ACT standards encompass the following overarching themes and/or foundational concepts:

A. Exploring and Defining the Fundamental Unifying Concepts, Organization, and Inquiry Techniques Underlying the Science of Biology

B. Investigating Life Processes at the Cellular Level and Understanding Both How These Processes Work and How They Are Maintained and Regulated

C. Delving Into Heredity by Investigating How Genetic Structures and Processes Provide the Mechanism for Continuity and Variety Among Organisms

D. Investigating Processes That Allow Populations to Change in Response to Different Environmental and Genetic Pressures

E. Identifying and Deciphering the Distinguishing Characteristics of All Categories of Living Things and Establishing the Genetic, Ancestral, and Behavioral Relationships Among Them

F. Analyzing the Ecological Processes by Which Living Things Interact With Their Environments and With Each Other

ACT Course Standards—Biology

A. Exploring and Defining the Fundamental Unifying Concepts, Organization, and Inquiry Techniques Underlying the Science of Biology (Note: Some of the process standards in this section are similar to those found in Chemistry and Physics)	
1. Scientific Inquiry	
a.	Identify and clarify biological research questions and design experiments
b.	Manipulate variables in experiments using appropriate procedures (e.g., controls, multiple trials)
c.	Collect, organize, and analyze data accurately and precisely (e.g., using scientific techniques and mathematics in experiments)
d.	Interpret results and draw conclusions, revising hypotheses as necessary and/or formulating additional questions or explanations
e.	Write and speak effectively to present and explain scientific results, using appropriate terminology and graphics
f.	Safely use laboratory equipment and techniques when conducting scientific investigations

2. Mathematics and Measurement in Science	
a.	Use appropriate SI units for length, mass, time, temperature, quantity, area, volume, and density, and describe the relationships among SI unit prefixes (e.g., centi-, milli-, kilo-) and how SI units are related to analogous English units
b.	Calculate the mean of a set of values
c.	Use graphical models, mathematical models, and simple statistical models to express patterns and relationships determined from sets of scientific data
3. Science in Practice	
a.	Describe the fundamental assumptions of science
b.	Assess how scientific and technological progress has affected other fields of study, careers, and aspects of everyday life
c.	Recognize and apply criteria that scientists use to evaluate the validity of scientific claims and theories
d.	Explain why scientific explanations must meet certain criteria (e.g., be consistent with experimental/observational evidence about nature, be open to critique and modification, be subject to peer review, use ethical reporting methods and procedures)
e.	Explain why all scientific knowledge is subject to change as new evidence becomes available to the scientific community
f.	Use a variety of appropriate sources (e.g., Internet, scientific journals) to retrieve relevant information; cite references properly
g.	Compare the goals and procedures followed in basic science with the goals and procedures of applied science and technology; discuss the important contributions of each and how citizens need to understand the ramifications of funding both endeavors
h.	Explain how the contributions of basic science drive the potential of applied science (e.g., advantages found in nature can be emulated for our own benefit/product development, such as observations of gecko feet suggesting new adhesives; understanding of basic cell biology leading to cancer treatments)
4. Foundations	
a.	Describe the biological criteria that need to be met in order for an organism to be considered alive
b.	Define and provide examples of each level of organization (e.g., biosphere, biome, ecosystem, community, population, multicellular organism, organ system, organ, tissue, cell, organelle, molecule, atom, subatomic particle)
c.	Design and conduct investigations appropriately using essential processes of scientific inquiry
d.	Use mathematics to enhance the scientific inquiry process (e.g., choosing appropriate units of measurement, graphing and manipulating experimental data)
5. Biochemistry	
a.	Identify subatomic particles and describe how they are arranged in atoms
b.	Describe the difference between ions and atoms and the importance of ions in biological processes
c.	Compare the types of bonding between atoms to form molecules
d.	Show how chemical reactions (e.g., photosynthesis, fermentation, cellular respiration) can be represented by chemical formulas
e.	Explain the difference between organic and inorganic compounds
f.	Explain the fundamental principles of the pH scale and the consequences of having the different concentrations of hydrogen and hydroxide ions
g.	Describe the general structure and function(s), including common functional groups, of monosaccharides, disaccharides, polysaccharides, carbohydrates, fatty acids, glycerol, glycerides, lipids, amino acids, dipeptides, polypeptides, proteins, and nucleic acids

h.	Describe the function of enzymes, including how enzyme-substrate specificity works, in biochemical reactions
i.	Define and explain the unique properties of water that are essential to living organisms
j.	Explain how cells store energy temporarily as ATP

B. Investigating Life Processes at the Cellular Level and Understanding Both How These Processes Work and How They Are Maintained and Regulated

1. Cells

a.	Analyze the similarities and differences among (a) plant versus animal cells and (b) eukaryotic versus prokaryotic cells
b.	Describe the functions of all major cell organelles, including nucleus, ER, RER, Golgi apparatus, ribosome, mitochondria, microtubules, microfilaments, lysosomes, centrioles, and cell membrane
c.	Illustrate how all cell organelles work together by describing the step-by-step process of the translation of an mRNA strand into a protein and its subsequent processing by organelles so that the protein is appropriately packaged, labeled, and eventually exported by the cell
d.	Contrast the structure and function of subcellular components of motility (e.g., cilia, flagella, pseudopodia)
e.	Explain how the cell membrane controls movement of substances both into and out of the cell and within the cell
f.	Explain how the cell membrane maintains homeostasis
g.	Describe and contrast these types of cell transport: osmosis, diffusion, facilitated diffusion, and active transport
h.	Identify the cellular sites of and follow through the major pathways of anaerobic and aerobic respiration, compare reactants and products for each process, and account for how aerobic respiration produces more ATP per monosaccharide
i.	Explain how photosynthetic organisms use the processes of photosynthesis and respiration
j.	Describe the basic process of mitosis

C. Delving Into Heredity by Investigating How Genetic Structures and Processes Provide the Mechanism for Continuity and Variety Among Organisms

1. Genetics

a.	Describe the basic structure and function of DNA, mRNA, tRNA, amino acids, polypeptides, and proteins (e.g., replication, transcription, and translation)
b.	Describe the experiments of major scientists in determining both the structure of DNA and the central dogma
c.	Use mRNA codon charts to determine amino acid sequences of example polypeptides
d.	Use mRNA codon charts to determine the effects of different types of mutations on amino acid sequence and protein structure (e.g., sickle cell anemia resulting from base substitution mutation)
e.	Describe how gene expression is regulated in organisms such that specific proteins are synthesized only when they are needed by the cell (e.g., allowing cell specialization)
f.	Describe the basic process of meiosis
g.	Identify and explain Mendel's law of segregation and law of independent assortment
h.	Explain how the process of meiosis reveals the mechanism behind Mendel's conclusions about segregation and independent assortment on a molecular level
i.	Define and provide an example of the following: genotype, phenotype, dominant allele, recessive allele, codominant alleles, incompletely dominant alleles, homozygous, heterozygous, and carrier

j.	Explain sex-linked patterns of inheritance in terms of some genes being absent from the smaller Y chromosome, and thus males (XY) having a different chance of exhibiting certain traits than do females (XX)
k.	Construct and interpret Punnett squares and pedigree charts (e.g., calculate and predict phenotypic and genotypic ratios and probabilities)
l.	Infer parental genotypes and phenotypes from offspring data presented in pedigree charts and from the phenotypic and genotypic ratios of offspring
m.	Describe the mode of inheritance in commonly inherited disorders (e.g., sickle cell anemia, Down syndrome, Turner's syndrome, PKU)
n.	Complete a major project relating to recombinant DNA, cloning, or stem cell research

D. Investigating Processes That Allow Populations to Change in Response to Different Environmental and Genetic Pressures

1. Evolution

a.	Describe the experiments of Redi, Needham, Spallanzani, and Pasteur to support or falsify the hypothesis of spontaneous generation
b.	Explain the biological definition of evolution
c.	Differentiate among chemical evolution, organic evolution, and the evolutionary steps along the way to aerobic heterotrophs and photosynthetic autotrophs
d.	Discuss Darwin's principle of survival of the fittest and explain what Darwin meant by natural selection
e.	Explain the influences of other scientists (e.g., Malthus, Wallace, Lamarck, Lyell) and of Darwin's trip on HMS *Beagle* in formulating Darwin's ideas about natural selection
f.	Contrast Lamarck's and Darwin's ideas about changes in organisms over time
g.	Provide examples of behaviors that have evolved through natural selection (e.g., migration, courtship rituals)
h.	Design, perform, and analyze a laboratory simulation of natural selection on a working population (e.g., teacher chooses prey items [hard candy, marshmallows]; students choose feeding adaptation [fork, toothpick, spoon] and hunt; students record results and then change prey or adaptation; and students analyze results using statistical methods)
i.	Specifically describe the conditions required to be considered a species (e.g., reproductive isolation, geographic isolation)
j.	Describe the basic types of selection, including disruptive, stabilizing, and directional
k.	Explain how natural selection and its evolutionary consequences (e.g., adaptation or extinction) provide a scientific explanation for the fossil record of ancient life-forms and the striking molecular similarities observed among the diverse species of living organisms
l.	Discuss evidence from the fields of geology, biochemistry, embryology, comparative anatomy, and comparative physiology that points to shared evolutionary relationships
m.	Explain how Earth's life-forms have evolved from earlier species as a consequence of interactions of (a) the potential of a species to increase its numbers and (b) genetic variability of offspring due to mutation and recombinations of DNA
n.	Distinguish between catastrophism, gradualism, and punctuated equilibrium

E. Identifying and Deciphering the Distinguishing Characteristics of All Categories of Living Things and Establishing the Genetic, Ancestral, and Behavioral Relationships Among Them
1. Animals
a. Identify major types of animal cells and tissues
b. Describe the major components and functions of physiological systems, including skeletal, muscle, circulatory, respiratory, digestive, urinary, endocrine, nervous, reproductive, and immune
2. Plants
a. Describe the basic mechanisms of plant processes, especially movement of materials and plant reproduction
b. Explain the functions of unique plant structures, including the cell wall, chloroplasts, and critical parts of the flower and the seed
c. Explain the interaction between pigments, absorption of light, and reflection of light
d. Describe the light-dependent and light-independent reactions of photosynthesis
e. Relate the products of the light-dependent reactions to the products of the light-independent reactions
f. Design and conduct an experiment (including the calculations necessary to make dilutions and prepare reagents) demonstrating effects of environmental factors on photosynthesis
3. Relationships Among Organisms
a. Explain how organisms are classified into a hierarchy of groups and subgroups based on similarities that reflect their evolutionary relationships
b. List each of the major levels in the hierarchy of taxa: kingdom, phylum, class, order, family, genus, and species
c. Explain the binomial nomenclature system
d. Construct and use a dichotomous taxonomic key
e. Distinguish between and among viruses, bacteria, and protists, and give examples of each
f. Explain classification criteria for fungi, plants, and animals
g. Compare the major divisions of animals
F. Analyzing the Ecological Processes by Which Living Things Interact With Their Environments and With Each Other
1. Ecology
a. Define and provide examples of biosphere, biome, ecosystem, community, population, species, habitat, and niche
b. Discuss biotic and abiotic factors that affect land and aquatic biomes
c. Discuss the role of beneficial bacteria (e.g., in the recycling of nutrients)
d. Explain how energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers
e. Explain how the amount of life any environment can support is limited by the available matter and energy and by the ability of ecosystems to recycle the residue of dead organic materials
f. Explain how organisms cooperate and compete in ecosystems and how interrelationships and interdependencies of organisms may generate ecosystems that are stable for thousands of years
g. Diagram the flow of energy using food webs, food chains, and pyramids (e.g., pyramid of energy, pyramid of biomass, and pyramid of numbers)

h. Describe examples of competition, symbiosis, and predation
i. Explain the concept of carrying capacity
j. Describe the growth of populations, including exponential and logistic growth (e.g., design and conduct an experiment investigating bacterial growth using appropriate calculations)
k. Explain the process of ecological succession, and describe the different communities that result
l. Read and describe current journal articles relating to environmental concerns (e.g., loss of biodiversity, habitat loss, pollution)
m. Discuss and evaluate the significance of human interference with major ecosystems (e.g., the loss of genetic diversity in cloned crops or animals)

ACT Course Standards Worksheet—Biology

This worksheet gives teachers an opportunity to compare their course content to ACT's QualityCore® program. Completing the worksheet also allows teachers who teach the same course to ensure their courses have similar outcomes.

Gap Analysis 1—Individual Teacher Review

This analysis allows individual teachers to identify "gaps" between ACT Course Standards and their course content. They should review the ACT standards on the following worksheet, then determine whether the ACT standard **is** or **is not** included in the course as it is currently taught. "Included" means the standard is taught and students are expected to demonstrate proficiency by the end of the course. "Not Included" means the standard is not taught in the course, is taught in another course, or is already mastered. In the "Gap 1" column on the worksheet, place an "I" for "Included" or an "NI" for "Not Included." Analyze any gaps between the current course standards and the ACT Course Standards. Identify reasons the standards receiving a "Not Included" designation are not included in the course.

Gap Analysis 2—Group Consensus

This analysis allows groups of teachers who teach the same course and who have completed Gap Analysis 1 individually to identify differences in how they evaluated the gaps between ACT Course Standards and current course standards. In the "Gap 2" column of the worksheet, place an "X" where members of the group differed in their assessment of whether a particular ACT standard is included in the course as it is currently taught.

The following questions can guide discussion of the gaps:

Overarching Questions

1. What should students know and be able to do before going to the next course?
2. Do all teachers teaching this course have a shared understanding of the intent or meaning of each course standard and topic area?

Gap Analysis 1 Questions

1. Which ACT Course Standards were identified as not included in the course?
2. What is the level of agreement among the group of teachers about the skills and knowledge that is or is not taught in the course?
3. Are there sound pedagogical reasons for not including specific ACT standards in the course?
4. What implications will any decisions have on students' future learning and academic achievement?

Gap Analysis 2 Questions

1. Which of the ACT Course Standards elicited differences of opinion?
2. What are the possible reasons for different opinions about the standards that are or are not included in the course?
3. Are there sound pedagogical reasons for including or not including these disputed standards in the course?
4. What implications will any decisions have on students' future learning and academic achievement?

Finally, document the necessary steps to address the outcomes of the discussion. Be sure to note whether course standards will be added, deleted, or modified; identify who will be responsible for communicating any changes to other teachers; and note any other decisions. Document responsibilities and establish a timetable for continuing the discussion and implementing the decisions.

NOTE: This course content review is most effective as a continuous process that generates feedback throughout the year. ACT recommends, at minimum, monthly status update meetings for teachers and departments involved in the review.

Biology Course Standards	Gap 1	Gap 2	Comments
A. Exploring and Defining the Fundamental Unifying Concepts, Organization, and Inquiry Techniques Underlying the Science of Biology **(Note: Some of the process standards in this section are similar to those found in Chemistry and Physics)**			
1. Scientific Inquiry			
a. Identify and clarify biological research questions and design experiments			
b. Manipulate variables in experiments using appropriate procedures (e.g., controls, multiple trials)			
c. Collect, organize, and analyze data accurately and precisely (e.g., using scientific techniques and mathematics in experiments)			
d. Interpret results and draw conclusions, revising hypotheses as necessary and/or formulating additional questions or explanations			
e. Write and speak effectively to present and explain scientific results, using appropriate terminology and graphics			
f. Safely use laboratory equipment and techniques when conducting scientific investigations			
2. Mathematics and Measurement in Science			
a. Use appropriate SI units for length, mass, time, temperature, quantity, area, volume, and density, and describe the relationships among SI unit prefixes (e.g., centi-, milli-, kilo-) and how SI units are related to analogous English units			
b. Calculate the mean of a set of values			
c. Use graphical models, mathematical models, and simple statistical models to express patterns and relationships determined from sets of scientific data			
3. Science in Practice			
a. Describe the fundamental assumptions of science			
b. Assess how scientific and technological progress has affected other fields of study, careers, and aspects of everyday life			

Biology Course Standards	Gap 1	Gap 2	Comments
c. Recognize and apply criteria that scientists use to evaluate the validity of scientific claims and theories			
d. Explain why scientific explanations must meet certain criteria (e.g., be consistent with experimental/ observational evidence about nature, be open to critique and modification, be subject to peer review, use ethical reporting methods and procedures)			
e. Explain why all scientific knowledge is subject to change as new evidence becomes available to the scientific community			
f. Use a variety of appropriate sources (e.g., Internet, scientific journals) to retrieve relevant information; cite references properly			
g. Compare the goals and procedures followed in basic science with the goals and procedures of applied science and technology; discuss the important contributions of each and how citizens need to understand the ramifications of funding both endeavors			
h. Explain how the contributions of basic science drive the potential of applied science (e.g., advantages found in nature can be emulated for our own benefit/product development, such as observations of gecko feet suggesting new adhesives; understanding of basic cell biology leading to cancer treatments)			
4. Foundations			
a. Describe the biological criteria that need to be met in order for an organism to be considered alive			
b. Define and provide examples of each level of organization (e.g., biosphere, biome, ecosystem, community, population, multicellular organism, organ system, organ, tissue, cell, organelle, molecule, atom, subatomic particle)			
c. Design and conduct investigations appropriately using essential processes of scientific inquiry			
d. Use mathematics to enhance the scientific inquiry process (e.g., choosing appropriate units of measurement, graphing and manipulating experimental data)			
5. Biochemistry			
a. Identify subatomic particles and describe how they are arranged in atoms			

Biology Course Standards	Gap 1	Gap 2	Comments
b. Describe the difference between ions and atoms and the importance of ions in biological processes			
c. Compare the types of bonding between atoms to form molecules			
d. Show how chemical reactions (e.g., photosynthesis, fermentation, cellular respiration) can be represented by chemical formulas			
e. Explain the difference between organic and inorganic compounds			
f. Explain the fundamental principles of the pH scale and the consequences of having the different concentrations of hydrogen and hydroxide ions			
g. Describe the general structure and function(s), including common functional groups, of monosaccharides, disaccharides, polysaccharides, carbohydrates, fatty acids, glycerol, glycerides, lipids, amino acids, dipeptides, polypeptides, proteins, and nucleic acids			
h. Describe the function of enzymes, including how enzyme-substrate specificity works, in biochemical reactions			
i. Define and explain the unique properties of water that are essential to living organisms			
j. Explain how cells store energy temporarily as ATP			
B. Investigating Life Processes at the Cellular Level and Understanding Both How These Processes Work and How They Are Maintained and Regulated			
1. Cells			
a. Analyze the similarities and differences among (a) plant versus animal cells and (b) eukaryotic versus prokaryotic cells			
b. Describe the functions of all major cell organelles, including nucleus, ER, RER, Golgi apparatus, ribosome, mitochondria, microtubules, microfilaments, lysosomes, centrioles, and cell membrane			

Biology Course Standards	Gap 1	Gap 2	Comments
c. Illustrate how all cell organelles work together by describing the step-by-step process of the translation of an mRNA strand into a protein and its subsequent processing by organelles so that the protein is appropriately packaged, labeled, and eventually exported by the cell			
d. Contrast the structure and function of subcellular components of motility (e.g., cilia, flagella, pseudopodia)			
e. Explain how the cell membrane controls movement of substances both into and out of the cell and within the cell			
f. Explain how the cell membrane maintains homeostasis			
g. Describe and contrast these types of cell transport: osmosis, diffusion, facilitated diffusion, and active transport			
h. Identify the cellular sites of and follow through the major pathways of anaerobic and aerobic respiration; compare reactants and products for each process, and account for how aerobic respiration produces more ATP per monosaccharide			
i. Explain how photosynthetic organisms use the processes of photosynthesis and respiration			
j. Describe the basic process of mitosis			
C. Delving Into Heredity by Investigating How Genetic Structures and Processes Provide the Mechanism for Continuity and Variety Among Organisms			
1. Genetics			
a. Describe the basic structure and function of DNA, mRNA, tRNA, amino acids, polypeptides, and proteins (e.g., replication, transcription, and translation)			
b. Describe the experiments of major scientists in determining both the structure of DNA and the central dogma			
c. Use mRNA codon charts to determine amino acid sequences of example polypeptides			
d. Use mRNA codon charts to determine the effects of different types of mutations on amino acid sequence and protein structure (e.g., sickle cell anemia resulting from base substitution mutation)			

Biology Course Standards	Gap 1	Gap 2	Comments
e. Describe how gene expression is regulated in organisms such that specific proteins are synthesized only when they are needed by the cell (e.g., allowing cell specialization)			
f. Describe the basic process of meiosis			
g. Identify and explain Mendel's law of segregation and law of independent assortment			
h. Explain how the process of meiosis reveals the mechanism behind Mendel's conclusions about segregation and independent assortment on a molecular level			
i. Define and provide an example of the following: genotype, phenotype, dominant allele, recessive allele, codominant alleles, incompletely dominant alleles, homozygous, heterozygous, and carrier			
j. Explain sex-linked patterns of inheritance in terms of some genes being absent from the smaller Y chromosome, and thus males (XY) having a different chance of exhibiting certain traits than do females (XX)			
k. Construct and interpret Punnett squares and pedigree charts (e.g., calculate and predict phenotypic and genotypic ratios and probabilities)			
l. Infer parental genotypes and phenotypes from offspring data presented in pedigree charts and from the phenotypic and genotypic ratios of offspring			
m. Describe the mode of inheritance in commonly inherited disorders (e.g., sickle cell anemia, Down syndrome, Turner's syndrome, PKU)			
n. Complete a major project relating to recombinant DNA, cloning, or stem cell research			
D. Investigating Processes That Allow Populations to Change in Response to Different Environmental and Genetic Pressures			
1. Evolution			
a. Describe the experiments of Redi, Needham, Spallanzani, and Pasteur to support or falsify the hypothesis of spontaneous generation			
b. Explain the biological definition of evolution			

Biology Course Standards	Gap 1	Gap 2	Comments
c. Differentiate among chemical evolution, organic evolution, and the evolutionary steps along the way to aerobic heterotrophs and photosynthetic autotrophs			
d. Discuss Darwin's principle of survival of the fittest and explain what Darwin meant by natural selection			
e. Explain the influences of other scientists (e.g., Malthus, Wallace, Lamarck, Lyell) and of Darwin's trip on HMS *Beagle* in formulating Darwin's ideas about natural selection			
f. Contrast Lamarck's and Darwin's ideas about changes in organisms over time			
g. Provide examples of behaviors that have evolved through natural selection (e.g., migration, courtship rituals)			
h. Design, perform, and analyze a laboratory simulation of natural selection on a working population (e.g., teacher chooses prey items [hard candy, marshmallows]; students choose feeding adaptation [fork, toothpick, spoon] and hunt; students record results and then change prey or adaptation; and students analyze results using statistical methods)			
i. Specifically describe the conditions required to be considered a species (e.g., reproductive isolation, geographic isolation)			
j. Describe the basic types of selection, including disruptive, stabilizing, and directional			
k. Explain how natural selection and its evolutionary consequences (e.g., adaptation or extinction) provide a scientific explanation for the fossil record of ancient life-forms and the striking molecular similarities observed among the diverse species of living organisms			
l. Discuss evidence from the fields of geology, biochemistry, embryology, comparative anatomy, and comparative physiology that points to shared evolutionary relationships			
m. Explain how Earth's life-forms have evolved from earlier species as a consequence of interactions of (a) the potential of a species to increase its numbers and (b) genetic variability of offspring due to mutation and recombinations of DNA			
n. Distinguish between catastrophism, gradualism, and punctuated equilibrium			

Biology Course Standards	Gap 1	Gap 2	Comments
E. Identifying and Deciphering the Distinguishing Characteristics of All Categories of Living Things and Establishing the Genetic, Ancestral, and Behavioral Relationships Among Them			
1. Animals			
a. Identify major types of animal cells and tissues			
b. Describe the major components and functions of physiological systems, including skeletal, muscle, circulatory, respiratory, digestive, urinary, endocrine, nervous, reproductive, and immune			
2. Plants			
a. Describe the basic mechanisms of plant processes, especially movement of materials and plant reproduction			
b. Explain the functions of unique plant structures, including the cell wall, chloroplasts, and critical parts of the flower and the seed			
c. Explain the interaction between pigments, absorption of light, and reflection of light			
d. Describe the light-dependent and light-independent reactions of photosynthesis			
e. Relate the products of the light-dependent reactions to the products of the light-independent reactions			
f. Design and conduct an experiment (including the calculations necessary to make dilutions and prepare reagents) demonstrating effects of environmental factors on photosynthesis			
3. Relationships Among Organisms			
a. Explain how organisms are classified into a hierarchy of groups and subgroups based on similarities that reflect their evolutionary relationships			
b. List each of the major levels in the hierarchy of taxa: kingdom, phylum, class, order, family, genus, and species			
c. Explain the binomial nomenclature system			

Biology Course Standards	Gap 1	Gap 2	Comments
d. Construct and use a dichotomous taxonomic key			
e. Distinguish between and among viruses, bacteria, and protists, and give examples of each			
f. Explain classification criteria for fungi, plants, and animals			
g. Compare the major divisions of animals			
F. Analyzing the Ecological Processes by Which Living Things Interact With Their Environments and With Each Other			
1. Ecology			
a. Define and provide examples of biosphere, biome, ecosystem, community, population, species, habitat, and niche			
b. Discuss biotic and abiotic factors that affect land and aquatic biomes			
c. Discuss the role of beneficial bacteria (e.g., in the recycling of nutrients)			
d. Explain how energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers			
e. Explain how the amount of life any environment can support is limited by the available matter and energy and by the ability of ecosystems to recycle the residue of dead organic materials			
f. Explain how organisms cooperate and compete in ecosystems and how interrelationships and interdependencies of organisms may generate ecosystems that are stable for thousands of years			
g. Diagram the flow of energy using food webs, food chains, and pyramids (e.g., pyramid of energy, pyramid of biomass, and pyramid of numbers)			

Biology Course Standards	Gap 1	Gap 2	Comments
h. Describe examples of competition, symbiosis, and predation			
i. Explain the concept of carrying capacity			
j. Describe the growth of populations, including exponential and logistic growth (e.g., design and conduct an experiment investigating bacterial growth using appropriate calculations)			
k. Explain the process of ecological succession, and describe the different communities that result			
l. Read and describe current journal articles relating to environmental concerns (e.g., loss of biodiversity, habitat loss, pollution)			
m. Discuss and evaluate the significance of human interference with major ecosystems (e.g., the loss of genetic diversity in cloned crops or animals)			