# Biology

## Pacing Guide and Unpacked Standards

GROVEPORT MADISON SCHOOLS

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# Groveport Madison Science Pacing Guide

| Biology | Cell Structure and Function | Cellular Processes | Standards for Literacy - Reading (Integrate throughout each topic) | Standards for Literacy- Writing (Integrate Throughout Each Topic) |
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| 1st 9 wks | **Cell Structure and function (B.C.1)**<br>● Structure/Function and Interrelatedness of Cell Organelles including<br>● Eukaryotic Cells and Prokaryotic Cells | **Cellular Processes (B.C.2)**<br>● Characteristics of Life<br>● Photosynthesis, Chemosynthesis, Cellular Respiration, biosynthesis of macromolecules | **RST.9-10.1** Cite specific textual evidence to support analysis.<br>**RST.9-10.2 (a,b)** Analyze central ideas & summarize.<br>**RST.9-10.3** Follow precisely a complex multistep procedure.<br>**RST.9-10.4** Determine the meaning of symbols & key terms.<br>**RST.9-10.5** Analyze text structure and key terms.<br>**RST.9-10.6** Analyze the author's purpose.<br>**RST.9-10.7** Translate quantitative or technical information into text or visual form.<br>**RST.9-10.8** Assess the evidence that supports the author's claim for solving a scientific problem.<br>**RST.9-10.9** Compare, contrast & note findings from various sources.<br>**RST.9-10.10** Read, comprehend & respond to science/technical texts. | **WHST.6-8.1 (a,b,c,d,e,f)** Write arguments to support claims & thesis.<br>**WHST.6-8.2 (a,b,c,d,e,f)** Write informative/explanatory texts. **WHST.6-8.4** Develop, organize & produce clear and coherent writing.<br>**WHST.6-8.5** Develop & strengthen writing through revision processes.<br>**WHST.6-8.6** Use technology to produce & publish writing.<br>**WHST.6-8.7** Conduct short research projects.<br>**WHST.6-8.8** Gather relevant information from credible digital & print sources.<br>**WHST.6-8.9** Support analysis & draw evidence from informational text.<br>**WHST.6-8.10** Write routinely over extended time frames. |
| **Biology** | **Heredity** | | | |
| 2nd 9 wks | ● Cellular Genetics **(B.H.1)**<br>● Structure and Function of DNA Sin Cells **(B.H.2)**<br>● Genetic Mechanisms and Inheritance **(B.H.3)**<br>● Mutations **(B.H.4)**<br>● Modern genetics **(B.H.5)** | | | |
| **Biology** | **Mechanisms of Evolution** | **Diversity of Life** | | |
| 3rd 9 wks | **Mechanisms (B.E.1)**<br>● Natural Selection<br>● Mutation<br>● Genetic Drift<br>● Gene flow (immigration, emigration)<br>● Sexual Selection | **Speciation (B.E.2)**<br>● Biological classification expanded to molecular evidence<br>● Variation of organisms within a species due to population genetics and gene frequency | | |
| **Biology** | **Diversity and Interdependence of Life** | | | |
| 4th 9wks | **Biodiversity (B.DI.1)**<br>● Genetic diversity<br>● Species diversity<br>**Ecosystems (B.DI.2)**<br>● Carrying Capacity<br>● Equilibrium and Disequilibrium<br>**Loss of Diversity (B.DI.3)**<br>● Climate change<br>● Anthropocene effects<br>● Extinction<br>● Invasive species | | | |

# Ohio's New Learning Standards-Clear Learning Targets

## B.C.1
## B.C.2

**Cells: Cell Structure and Function**
**Structure, function and interrelatedness of cell organelles, Eukaryotic cells and prokaryotic cells**

**Cells: Cellular Processes**
**Characteristics of Life Regulated by Cellular Processes, Photosynthesis, Chemosynthesis, Cellular Respiration, Biosynthesis of Macromolecules**

**Essential Understandings:**

- The cell is a system that conducts a variety of functions associated with life. Details of cellular processes such as photosynthesis, chemosynthesis, cellular respiration, cell division and differentiation are studied at this grade level. Additionally, cellular organelles studied are cytoskeleton, Golgi complex and endoplasmic reticulum.
- From about 4 billion years ago to about 2 billion years ago, only simple, single-celled microorganisms are found in the fossil record. Once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.
- Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape. Within the cell are specialized parts for the transport of materials, energy transformation, protein building, waste disposal, information feedback and movement. In addition to these basic cellular functions, most cells in multicellular organisms perform some specific functions that others do not.
- A living cell is composed of a small number of elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules. The essential functions of cells involve chemical reactions that involve water and carbohydrates, proteins, lipids and nucleic acids. A special group of proteins, enzymes, enables chemical reactions to occur within living systems.
- Cell functions are regulated. Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Most cells function within a narrow range of temperature and pH. At very low temperatures, reaction rates are slow. High temperatures and/or extremes of pH can irreversibly change the structure of most protein molecules. Even small changes in pH can alter how molecules interact.
- The sequence of DNA bases on a chromosome determines the sequence of amino acids in a protein. Proteins catalyze most chemical reactions in cells. Protein molecules are long, usually folded chains made from combinations of the 20 typical amino-acid sub-units found in the cell. The function of each protein molecule depends on its specific sequence of amino

**Vocabulary**

Unicellular
Organelle
Cytoskeleton
Golgi Complex
Endoplasmic Reticulum
Membrane
Carbohydrate
Protein
Lipid
Amino Acid
Nucleic Acid
Enzyme
Photosynthesis
Cellular Respiration
Cell Division
Cell Differentiation
pH
Energy Transformation
Chemosynthesis

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| acids and the shape the chain takes as a result of that sequence.<br>Note 1: The idea that protein molecules assembled by cells conduct the work that goes on inside and outside the cells in an organism can be learned without going into the biochemical details. It is sufficient for students to know that the molecules involved are different configurations of a few amino acids and that the different shapes of the molecules influence what they do.<br>Note 2: The concept of the cell and its parts as a functioning system is more important than memorizing parts of the cell. | |
| **Essential Skills:** | The students can explain that the cell is a functioning system (e.g., regulation, homeostasis, cell cycle, and transport);<br>The students can identify and describe that the cell has specialized parts for the transport of materials, energy transformation, protein building, waste disposal, and movement;<br>The students can describe the role of water and organic molecules in cells (lipids, carbohydrates, nucleic acids, proteins);<br>The students can understand the properties of the cellular environment that affect shape and function of enzymes (e.g., pH, temperature, concentration);<br>The students can diagram the transformation of energy through ATP and cycling of carbon through cellular processes in cells (e.g., photosynthesis, cellular respiration).<br>The students can investigative scenarios that explore abiotic effects on the cell cycle;<br>The students can investigative scenarios that determine factors that affect the activity of enzymes on their substrates;<br>The students can investigate real-world applications of cells that play a foundational role in engineering and industry (e.g., fermentation, medicine);<br>The students can interrupt diagrams of photosynthesis, cellular respiration, and/or chemosynthesis connected to a real-world scenario;<br>The students can interrupt diagrams of cells from a variety of organisms connected to a real-world scenario. (e.g., plant vs. animal cells, prokaryotic vs. eukaryotic, cells with or without potassium pump);<br>The students can interrupt diagrams of cellular transport.<br>The students can create and interpret graphs or data (e.g., temperature, pH, light, concentration) to explain the rate of enzyme activity in a cell;<br>The students can explain how the structure of cellular parts facilitates their function;<br>The students can describe regulation of the cellular environment (e.g., homeostasis);<br>The students can compare organic molecules and their role in cells;<br>The students can describe how photosynthesis and cellular respiration impact the concentration of chemicals in a system;<br>The students can use a diagram of the basic stages of photosynthesis (light and dark reactions) identify the major reactants/products ($CO_2$, $H_2O$, ATP, $O_2$, glucose) involved in each stage.<br>The students can explain how cell components work together to perform the functions of the cell;<br>The students can analyze graphs displaying data about enzyme activity and how that impacts a cell;<br>The students can design an experiment to determine the effect of external factors (e.g., pH, temperature, concentration) on the cellular function (e.g., transport, enzyme rate, photosynthesis, cellular respiration);<br>The students can evaluate or improving the design of an industrial application of cellular processes (e.g., optimal environment for fermentation, genetically modified organisms). |
| **DO NOT ASSESS** | • Steps of protein synthesis;<br>• Names of specific enzymes; |

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| | • Memorization of formulas and detailed chemical reactions associated with cellular functions;<br>• Memorization of cell parts and their functions (basic cell parts and functions are assessed at Grade 6);<br>• Electron transport chains. |

**Misconceptions**

- The Annenberg Media series *Minds of Our Own* offers *Lessons From Thin Air*, which illustrates the misconceptions that students have about photosynthesis and plant growth, at http://www.learner.org/resources/series26.html.
- The website (http://www.neisd.net/curriculum/SchImprov/sci/program/misconceptions_inter.htm#cells) provides basic misconceptions for multiple topics as well as explanations of the misconceptions and ways to address these.
- Southern Nevada RPDP: (http://rpdp.net/sciencetips_v2/L12B3.htm#top) provides a comprehensive list of student misconceptions as aligned to the standards.

**Instructional Strategies and Resources**

- Optical enhancements can be used to alter the image produced by a light microscope to show greater detail. Compare cells using unaltered Compound Light Microscopes with the same cells using Darkfield, Rheinberg and Polarization techniques.
- Examine the role of bacteria in food production. Determine what types of bacteria are used and how it impacts (pH levels, gases produced, impact on proteins) the production of the product (yogurt, cheese).
- Determine the limitations of and uses of DNA in a criminal investigation.

**Career Connections:** http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

**Criteria for Success (Performance Level Descriptors)**

**Limited**: Identify different types of cells (e.g., prokaryotic vs. eukaryotic, plant vs. animal); Identify the products of photosynthesis and cellular respiration (e.g. oxygen, carbon dioxide, glucose, etc.); Recall that cell components work together to perform the functions of the cell.

**Basic**: Explain how the functions of cellular parts are made possible by their structures (e.g., the pores in the nuclear envelope, the channel proteins of the cell membrane); Use a diagram to model the transport of particles into and out of the cell.

**Proficient**: Interpret graphs or data (e.g., temperature, pH, light, concentration) to explain the rate of enzyme activity in a cell; Describe regulation of the cellular environment (e.g., homeostasis); Determine an amino acid sequence from a DNA/RNA base sequence using a codon chart; Describe how cell components work together to perform the functions of the cell; Plan and conduct an experiment to determine the effects of external factors (e.g., pH, temperature, concentration) on cellular functions (e.g., transport, enzyme rate, photosynthesis, cellular respiration).

**Advanced**: Design a model to explain the transformation of energy through ATP and cycling of carbon through cellular processes in cells (e.g., photosynthesis, cellular respiration); Explain how the cellular environment affects the mechanical operation of an enzyme (e.g., reactant, active site, product).

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| **Accelerated**: Develop and test a hypothesis to improve the design of an industrial application of cellular processes (e.g., optimal environment for fermentation, genetically modified organisms); Use mathematical reasoning to analyze graphs displaying data about enzyme activity and how it impacts a cell. | |
| **Prior Knowledge**<br><br>**Middle School:** Cell theory, was a main topic which focused on the cell as a system itself (single-celled organism) and as part of larger systems (multicellular organism), sometimes as part of a multicellular organism, always as part of an ecosystem. | **Future Knowledge**<br><br>No further information on cellular structure will be taught. |

# Ohio's New Learning Standards-Clear Learning Targets

## B.H.1-5

**Heredity**
**B.H.1: Cellular genetics**
**B.H.2: Structure and function of DNA in cells**
**B.H.3: Genetic mechanisms and inheritance**
**B.H.4: Mutations**
**B.H.5: Modern Genetics**

**Essential Understandings:**

This topic focuses on the explanation of genetic patterns of inheritance. In middle school, students learn that living things are a result of one or two parents, and traits are passed on to the next generation through both asexual and sexual reproduction. In addition, they learn that traits are defined by instructions encoded in many discrete genes and that a gene may come in more than one form called alleles.

At the high school level, the explanation of genes is expanded to include the following concepts:

- Life is specified by genomes. Each organism has a genome that contains all of the biological information needed to build and maintain a living example of that organism. The biological information contained in a genome is encoded in its deoxyribonucleic acid (DNA) and is divided into discrete units called genes.
- Genes are segments of DNA molecules. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein. Inserting, deleting or substituting segments of DNA molecules can alter genes.
- An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm or have little or no effect on the offspring's success in its environments.
- Gene mutations (when they occur in gametes) can be passed on to offspring.
- Genes code for protein. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein.
- "The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Different genes are active in different types of cells, influenced by the cell's environment and past history." (AAAS)

In high school biology, Mendel's laws of inheritance (introduced in grade 8) are interwoven with current knowledge of DNA and chromosome structure and function to build toward basic knowledge of modern genetics. Sorting and recombination of genes in sexual reproduction and meiosis specifically result in a variance in traits of the offspring of any two parents and explicitly connect the knowledge to evolution.

**Vocabulary**

Conduct
Amino Acid
Protein
Insertion
Deletion
Substitution
Chromosome
Mutation
Genetic Code

Gamete
Chi-Square
Recombination
Dihybrid Cross
Sexual Reproduction
Pleiotropy
Meiosis
Epistasis
Incomplete Dominance
Polygenic
Sex-Linked Traits
Cloning
Altered Gene
Gene Mutation

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| The gene interactions described in middle school were limited primarily to dominance and co-dominance traits. In high school genetic mechanisms, both classical and modern including incomplete dominance, sex-linked traits, goodness of fit test (Chi-square) and dihybrid crosses are investigated through real- world examples. Dihybrid crosses can be used to explore linkage groups. Gene interactions and phenotypic effects can be introduced using real-world examples (e.g., polygenic inheritance, epistasis, pleiotropy). It is imperative that the technological developments that lead to the current knowledge of heredity be included in the study of heredity. For example, the development of the model for DNA structure was the result of the use of technology and the studies and ideas of many scientists. Watson and Crick developed the final model, but did not do the original studies. | |

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| **Essential Skills:** | The students can understand that genes are segments of DNA and code for protein;<br>The students can understand the concept of differentiation – although all cells have identical genetic information, different genes are active in different types of cells;<br>The students can identify cellular and molecular mechanisms for inheritance and the expression of genetic information (e.g., complementary base pairs in DNA and RNA, transcription/translation);<br>The students can comprehend the importance of crossing over, independent assortment, and recombination in producing variation in traits as a result of meiosis;<br>The students can connect Mendel's laws of segregation and independent assortment to the movement of chromosomes (crossing over, sorting, and recombination) during meiosis;<br>The students can explain gene mutations and their short-term and long-term implications;<br>The students can comprehend Mendelian and Non-Mendelian inheritance (e.g., dihybrid crosses, sex-linked traits, linkage, chi-square test);<br>The students can describe the goals of genetic engineering and the role of restriction enzymes.<br>The students can interpret diagrams of DNA to illustrate protein synthesis;<br>The students can interpret diagrams that illustrate crossing over;<br>The students can identify real-world scenario in which chi-squared test data are given;<br>The students can use a codon chart to build a protein;<br>The students can differentiate between parent and daughter cells before and after meiosis;<br>The students can interpret diagrams of a variety of genetic crosses;<br>The students can interpret diagrams of gene sequences showing a mutation;<br>The students can understand different scenarios involving applications of biotechnology and genetic engineering such as cloning, gene therapy, or gel electrophoresis;<br>The students can describe basic historical data from DNA discoveries.<br>The students can demonstrate how the complementary DNA base pairing within genes determines the sequence of amino acids in a protein;<br>The students can illustrate how non-Mendelian genetics affects inheritance (including Punnett squares); The students can predict the probability of two traits in offspring given the parental genotypes;<br>The students can compare and contrast the genetic makeup of two different types of cells in the same organism;<br>The students can be given chi-squared test data, and make an inference about the inheritance of a set of genes;<br>The students can demonstrate how sorting and recombination of genes in sexual reproduction and meiosis result in variation of traits |

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| | in offspring.<br><br>The students can explain how gene mutations might impact organisms;<br>The students can interpret data from a real-world scenario involving biotechnology (e.g., gel electrophoresis, gene therapy, cloning);<br>The students can explain the importance of historical discoveries after Mendel to our understanding of the structure and function of DNA.<br>The students can explain the scientific implications of a biotechnology (e.g., oil-eating bacteria);<br>The students can be given a scenario, making and justifying conclusions about the type of inheritance involved;<br>The students can design or conduct an investigation involving genetics and inheritance (e.g., fruit flies, fast plants, matching genes to traits);<br>The students can explain the effect that a gene mutation can have on protein synthesis or traits. |
| **DO NOT ASSESS** | • Examples using human genetics;<br>• Mechanisms of differentiation;<br>• Monohybrid crosses (including co-dominance) except those beyond Grade 8 (incomplete dominance and sex-linked traits are appropriate for high school);<br>• Mitosis is considered in Grade 6, not assessed in high school;<br>• Specific molecular structure of nucleic acids or types of RNA (e.g., sugars, single vs. double strands);<br>• Labeling specific phases of meiosis;<br>• Details about the steps of replication, transcription/translation, and protein synthesis (e.g., identifying or naming enzymes, introns or exons);<br>Details about genetic engineering procedures. |
| **Misconceptions**<br>• The University of Utah provides information about misconceptions related to cloning.<br>• Southern Nevada RPDP (http://rpdp.net/sciencetips_v2/L12D2.htm#misconcept) provides a comprehensive list of misconceptions in genetics and heredity. | |

**Instructional Strategies and Resources**

- The National Institute of the Health provides a timeline of the milestones in genetics. Stories, archival images and original scientific publications tell the historical story of genetic discoveries. Students can trace how new understandings about the transmission of traits developed new questions that led to new discoveries. One major milestone is the Human Genome Project. DNA Learning Center features an interactive site that provides detailed background knowledge on how genomes are developed and used for research.
- Mendelian Genetics provides clear explanations for basic genetics; this link connects to an explanation and example of Chi-square.
- Cold Spring Harbor Laboratory's Dolan DNA Learning Center provides DNA Molecules for models that help to illustrate some of the more abstract concepts associated with DNA. Scroll down the page to the *More 3-D Animation Library*.

**Career Connections**

http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

**Criteria for Success (Performance Level Descriptors)**

**Limited:** Recall that DNA is the blueprint for cell structures and processes; Name the complementary base pairs in DNA.

**Basic**: Recognize the structural and base pairing differences between DNA and RNA; Identify that the sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein; Recall that the insertion, deletion or substitution of segments of DNA are mutations which alter genes; Identify how an altered gene may be passed on to every cell that develops from that cell; Describe the concept of differentiation—although all cells have identical genetic information, different genes are active in different types of cells.

**Proficient**: Explain the difference in possible outcomes when gene mutations occur in gametes or somatic cells; Predict and interpret non-Mendelian monohybrid and Mendelian dihybrid crosses; Recognize which tests are used to compare actual results to predicted results in genetic investigations (e.g. chi-squared, gel electrophoresis); Explain the steps of protein synthesis from DNA transcription to translation; Explain how sorting and recombination of genes in sexual reproduction and meiosis result in variations of traits in offspring.

**Accelerated**: Investigate Mendelian and non-Mendelian inheritance (e.g., dihybrid crosses, sex-linked traits, linkage) to compare predicted results to actual results (e.g., chi-square goodness of fit); Interpret data from a real-world scenario involving biotechnology (e.g., gel electrophoresis).

**Advanced**: none

**Prior Knowledge**

**Third Grade:** Plants and Animal life cycles and offspring resemble their parents.

**Eighth Grade:** Reproduction, Mendelian Genetics, inherited traits and diversity of species), this topic focuses on the explanation of genetic patterns of inheritance. In middle school, students learn that living things are a result of one or two parents, and traits are passed on to the next generation through both asexual and sexual reproduction. In addition, they learn that traits are defined by instructions encoded in many discrete genes and that a gene may come in more than one form called alleles.

**Future Knowledge**

No further information on heredity will be taught.

## Ohio's New Learning Standards-Clear Learning Targets

# B.E.1-2

**Evolution**

**B.E.1: Mechanisms**
**Natural selection, Mutation, Genetic drift, Gene flow (immigration, emigration), Sexual selection**

**B.E.2: Speciation**
**Biological classification expanded to molecular evidence, Variation of organisms within a species due to population genetics and gene frequency**

**Essential Understandings:**

- Biological evolution explains the natural origins for the diversity of life. Emphasis shifts from thinking in terms of selection of individuals with a particular trait to changing proportions of a trait in populations. The study of evolution must include Modern Synthesis, the unification of genetics and evolution and historical perspectives of evolutionary theory. The study of evolution must include gene flow, mutation, natural selection, genetic drift, sexual selection and Hardy Weinberg's law.

- The basic concept of biological evolution is that the Earth's present-day species descended from earlier, common ancestral species. At the high school level, the term natural selection is used to describe the process by which traits become more or less common in a population due to consistent environmental effects upon the survival or reproduction of the individual with the trait. Mathematical reasoning must be applied to solve problems, (e.g., use Hardy Weinberg's law to explain gene frequency patterns in a population).

- Modern ideas about evolution provide a natural explanation for the diversity of life on Earth as represented in the fossil record, in the similarities of existing species and in modern molecular evidence. From a long-term perspective, evolution is the descent with modification of different lineages from common ancestors.

- Different phenotypes result from new combinations of existing genes or from mutations of genes in reproductive cells. At the high school level, the expectation is to combine grade-8 knowledge with explanation of the internal structure and function of chromosomes. Natural selection works on the phenotype.

Populations evolve over time. Evolution is the consequence of the interactions of:

1. The potential for a population to increase its numbers;
2. The genetic variability of offspring due to mutation and recombination of genes;
3. A finite supply of the resources required for life; and
4. The differential survival and reproduction of individuals with the specific phenotype.

**Vocabulary**

Trait
Evolution
Genetic Variability
Gene Flow
Mutation
Population
Speciation
Hardy-Weinberg
Natural Selection
Sexual Selection
Genetic Drift
Diversity
Trait
Phenotype
Recombination
Classification system
Morphological comparisons
Cladogram

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| • Mutations are described in the content elaboration for Heredity. Apply the knowledge of mutation and genetic drift to real-world examples.<br>• Recent molecular-sequence data generally, but not always, support earlier hypotheses regarding lineages of organisms based upon morphological comparisons.<br>• Heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment.<br>• When an environment changes, the survival value of inherited characteristics may change. This may or may not cause a change in species that inhabit the environment. Formulate and revise explanations for gene flow and sexual selection based on real-world problems. | |
| **Essential Skills:** | The students can comprehend evolution of a species (change in gene frequency in a population and the Hardy-Weinberg Law);<br>The students can differentiate between mechanisms of speciation (gene flow, mutation, speciation, natural selection, genetic drift, sexual selection);<br>The students can describe evidence for evolution (e.g., fossil record, molecular and structural homology, biogeography).<br>The students can state evidence of evolutionary theory from real-world examples (e.g., antibiotic resistant bacteria, fossil record, molecular and structural homology);<br>The students can interpret cladograms showing relationships between species;<br>The students can comprehend different scenarios in which environmental changes influence selective pressure on a population;<br>The students can give examples of speciation between isolated populations (e.g., leopard frogs, anole lizard, Central American hummingbirds);<br>The students can interpret tables or data showing gene frequency changes over time (e.g., bottleneck cheetahs).<br>The students can use mathematical reasoning related to the Hardy-Weinberg Law to explain or predict changes in a population;<br>The students can predict how factors affect evolution of a population or populations;<br>The students can give evidence, determining the relatedness of groups;<br>The students can compare the survivability of traits between populations in different environments; The students can compare evolutionary mechanisms illustrated in a variety of populations.<br>The students can use mathematical reasoning related to Hardy-Weinberg's Law to explain or predict changes in a population;<br>The students can be given data and/or a scenario, making and justifying a conclusion about evolutionary mechanisms in a population;<br>The students can explain how variations within populations in a changing environment can lead to evolution;<br>The students can describe how speciation occurred in two related populations;<br>The students can use examples to explain how evidence supports the theory of evolution;<br>The students can give a real-world example, explaining and predict how a population has responded to environmental changes. |

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| **DO NOT ASSESS** | • Human evolution;<br>• Specific type of mutations;<br>• The fossil record as evidence for biodiversity, diversity within a species, and the fact that most species that have lived on Earth are now extinct (this assessed in Grade 8);<br>• Formation of fossils and/or geologic strata;<br>• Calculations using the Hardy-Weinberg Law;<br>• Genes as they relate to specific traits in individuals;<br>• Evolution using the examples of peppered moths and Darwin's finches. |
| **Misconceptions**<br>The Southern Nevada Regional Professional Development Center provides a list of common student naïve conceptions about evolution. | |
| **Instructional Strategies and Resources**<br>• University of Colorado's PhET provides an interactive simulation of natural selection for a population of rabbits. Environmental factors can be altered and mutations introduced to show how the population would change over time.<br>• Annenberg's Rediscovering Biology: Molecular to Global Perspectives, Session 3, Evolution and Phylogenetics is a tutorial for teachers on some of the current advances in biology.<br>• The National Science Teachers Association offers a position paper on the Teaching of Evolution.<br>• Online course in evolutionary biology for teachers is provided by the Public Broadcasting System: Evolution. | |
| **Career Connections:** http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/ | |

**Criteria for Success (Performance Level Descriptors)**

**Limited**: Recall that populations can change from generation to generation due to selective pressures; Given a scenario, predict which traits may increase survivability in a species; State that organisms are classified on morphological and molecular evidence.

**Basic**: Identify that variations within a population in a changing environment can lead to evolution; Provide an example of natural selection.

**Proficient**: Determine how variations within populations in a changing environment can lead to evolution; Given a real-world example, predict and provide evidence to support how a population has responded to environmental changes; Interpret a cladogram showing relationships among species.

**Accelerated**: Explain why a population is or is not in Hardy-Weinberg equilibrium based on given data or conditions (e.g., no mutation is occurring, mating is random); Given scenarios in which technological innovations could potentially influence selective pressure on a population, outline possible advantages and disadvantages for use of the technology using scientific concepts; Given data and/or a scenario, make and justify a conclusion about evolutionary mechanisms in a population.

**Advanced**: Analyze data and provide evidence for the selection of an evolutionary mechanism that has occurred in a given population; Design or simulate a population growth model by manipulating environmental conditions; Explain the relative effects of different mutations (e.g., substitution or deletion resulting in a frameshift) in DNA on the operation of protein because of changes in sequence of amino acids; Interpret the results of experiments to identify evidence for core ideas in biology (e.g., structure of DNA, DNA semi-conservative replication, mRNA read three bases at a time).

| **Prior Knowledge** | **Future Knowledge** |
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| **Elementary School:** Evolution concepts include the relationship between organisms and the environment, parent and offspring, and an introduction to the fossil record and extinction.<br>**Middle School:** Concepts include biodiversity (as part of biomes) and speciation, further exploration of the fossil record and Earth history, changing environmental conditions (abiotic factors), natural selection and biological evolution. | No further information on evolution will be taught. |

## Ohio's New Learning Standards-Clear Learning Targets

# B.DI.1-3

**Diversity and Interdependence of Life**
**B.DI.1: Biodiversity**
**Genetic diversity, Species diversity**
**B.DI.2: Ecosystems**
**Equilibrium and disequilibrium, Carrying capacity**
**B.DI.3: Loss of Diversity**
**Climate change, Anthropocene effects, Extinction, Invasive species**

**Essential Understandings:**

- This topic focuses on the study of diversity and similarity at the molecular level of organisms. Additionally, the effectsof physical/chemical constraints on all biological relationships and systems are investigated.
- The great diversity of organisms and ecological niches they occupy result from more than 3.5 billion years of evolution. Some ecosystems can be reasonably persistent over hundreds or thousands of years. Like many complex systems, ecosystems tend to have cyclic fluctuations around state of rough equilibrium. In the long run, however, ecosystems always change as geological or biological conditions vary. Misconceptions about population growth capacity, interspecies and intra-species competition for resources, and what occurs when a species immigrates to or emigrates from ecosystems are included in this topic. Technology must be used to access real-time/authentic data to study population changes and growth in specific locations.
- Recent molecular-sequence data generally support earlier hypotheses regarding lineages of organisms based upon morphological comparisons. Both morphological comparisons and molecular evidence must be used to describe biodiversity (cladograms can be used to address this).
- Organisms transform energy (flow of energy) and matter (cycles of matter) as they survive and reproduce. The cycling of matter and flow of energy occurs at all levels of biological organization, from molecules to ecosystems. At the high school level, the concept of energy flow as unidirectional in ecosystems is explored.

**Vocabulary**

Niche
Ecosystems
Equilibrium
Homeostasis
Growth capacity
Classification
Immigration
Resources
Emigration
Competition
Biodiversity
Cladogram
Diversity
Classification System
Morphological comparisons
Morphology
Interspecies

- Mathematical graphing and algebraic knowledge (at the high school level) must be used to explain concepts of carrying capacity and homeostasis within biomes. Use real-time data to investigate population changes that occur locally or regionally. Mathematical models can include exponential growth model and the logistic growth model. The simplest version of the logistic growth model is ; the only new variable added to the exponential model is K for carrying capacity.

**Population Growth Rate = rN(K-N)/K**

Note 1: Exponential growth equation in simplest form, change in population size N per unit time t is a product of r (the per capita reproductive rate) and N (population size).

Note 2: Carrying capacity is defined as the population equilibrium sized when births and deaths are equal; hence Population Growth Rate = 0.

Note 3: Constructing food webs/food chains to show interactions between organisms within ecosystems was covered in upper elementary school and middle school; constructing them as a way to demonstrate content knowledge is not appropriate for this grade. Students may use these diagrams to help explain real-world relationships or events within an ecosystem, but not to identify simple trophic levels, consumers, producers, predator-prey and symbiotic relations.

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| **Essential Skills:** | The students can understand cyclical fluctuations of ecosystems around a rough state of equilibrium;<br>The students can describe energy flow at ecosystem and molecular levels;<br>The students can classify using morphological and molecular evidence;<br>The students can explain diversity of species and ecological niches resulting from billions of years of evolution;<br>The students can interpret models describing carrying capacity and homeostasis within ecosystems supported with mathematical evidence**.**<br>The students can interpret population graphs or charts containing authentic, real-world data;<br>The students can interpret diagrams of food chains and webs to explain real-world relationships or events within an ecosystem (e.g., biomagnification, invasive species, energy flow and nutrient cycle changes);<br>The students can comprehend scenarios involving remediation and habitat restoration programs (e.g., fish populations in the Great Lakes);<br>The students can comprehend scenarios involving niche partitioning, competition for resources, immigration/emigration from an ecosystem, or environmental change;<br>The students can interpret and analyze Cladograms;<br>The students can analyze data tables showing genetic relatedness between organisms.<br>The students can use mathematical reasoning to interpret exponential or logistic growth models;<br>The students can design or simulate a population growth model by manipulating environmental conditions;<br>The students can when given population graphs or charts containing data, analyzing the history or predict the future of an ecosystem; The students can predict the effect of geological, biological, or environmental changes on a population within an ecosystem (e.g.,<br>climate change, deforestation, human development);<br>The students can complete a cladograms to determine relationships among organisms;<br>The students can predict the effect of geological, biological, or environmental changes on a population within an ecosystem (e.g., climate change, deforestation, human development);<br>The students can discuss the implications of technology or engineering on an ecosystem (e.g., power plant increasing water temperature);<br>The students can use mathematical models to explain carrying capacity and homeostasis within ecosystems;<br>The students can be given a scenario, designing an experiment to predict the effect of several possible factors on the carrying capacity.<br>The students can use cladograms to compare and contrast the degree of relatedness between organisms. |

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| **DO NOT ASSESS** | • Identification of trophic levels, consumers, producers, predator-prey and symbiotic relationships;<br>• Construction of food chains and/or webs;<br>• Features or definition of biomes;<br>• Steps of biogeochemical cycles;<br>• Memorization of Linnaeus' classification of living things;<br>• Calculations involving logistic growth or other models. |

**Misconceptions**

- Binghamton University provides a general list for of naïve concepts for life science called Overcoming Ecological Misconceptions.
- **Southern Nevada RPDP** (http://rpdp.net/sciencetips_v2/L12D1.htm#misconcept; has an extensive list of student misconceptions concerning evolution.

**Instructional Strategies and Resources**

- Examine wildlife populations in Ohio like bald eagles, beavers or white-tailed deer. The Ohio Department of Natural Resources provides population data over the years. Examine the factors that have impacted the carrying capacity.
- The Southern Nevada Regional Professional Development Center provides a tutorial, which explains the links between classification systems and evolution.

**Career Connections:** http://www.collegexpress.com/interests/science-and-engineering/articles/studying-sciences/science-majors-and-potential-jobs/

**Criteria for Success (Performance Level Descriptors)**

**Limited**: Recall that ecosystems change as geological and biological conditions vary.

**Basic**: Describe one process by which an organism transforms energy and matter as part of an ecosystem; Recall how carrying capacity limits a population.

**Proficient**: Given population graphs or charts containing data, determine the changes to an ecosystem, including carrying capacity; Predict the effect of geological, biological and/or environmental changes on a population within an ecosystem (e.g., shifting weather patterns, loss of habitat).

**Accelerated**: Given population graphs or charts containing data, analyze current and past data to predict and provide evidence to support their predicted changes in an ecosystem; Use mathematical models (e.g. exponential or logistic growth) to explain carrying capacity and homeostasis within ecosystems; Complete cladograms to determine relationships among organisms.

**Advanced**: none

## Prior Knowledge

**Elementary School:** Interactions of organisms within their environment and the law of conservation of matter and energy, food webs
**Middle School:** Flow of energy through organisms, biomes and biogeochemical cycles.

## Future Knowledge

No further information on diversity and independence of life will be taught.

# Common Core Standards for Literacy in Science – Reading Standards 9-10

**Key Ideas and Details:**

**CCSS.ELA-LITERACY.RST.9-10.1**

***Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.***

**CCSS.ELA-LITERACY.RST.9-10.2**

Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

**CCSS.ELA-LITERACY.RST.9-10.3**

Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

**Craft and Structure:**

**CCSS.ELA-LITERACY.RST.9-10.4**

Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9-10 texts and topics*.

**CCSS.ELA-LITERACY.RST.9-10.5**

Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).

**CCSS.ELA-LITERACY.RST.9-10.6**

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

**Integration of Knowledge and Ideas:**

**CCSS.ELA-LITERACY.RST.9-10.7**

Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

**CCSS.ELA-LITERACY.RST.9-10.8**

Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

**CCSS.ELA-LITERACY.RST.9-10.9**

Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

**Range of Reading and Level of Text Complexity:**

**CCSS.ELA-LITERACY.RST.9-10.10**

By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.

# Common Core Standards for Literacy in Science – Writing Standards 9-10

**Text Types and Purposes:**

**CCSS.ELA-LITERACY.WHST.9-10.1**
Write arguments focused on *discipline-specific content*.

**CCSS.ELA-LITERACY.WHST.9-10.1.A**
Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

**CCSS.ELA-LITERACY.WHST.9-10.1.B**
Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.

**CCSS.ELA-LITERACY.WHST.9-10.1.C**
Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

**CCSS.ELA-LITERACY.WHST.9-10.1.D**
Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

**CCSS.ELA-LITERACY.WHST.9-10.1.E**
Provide a concluding statement or section that follows from or supports the argument presented.

**CCSS.ELA-LITERACY.WHST.9-10.2**
Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

**CCSS.ELA-LITERACY.WHST.9-10.2.A**
Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

**CCSS.ELA-LITERACY.WHST.9-10.2.B**
Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

**CCSS.ELA-LITERACY.WHST.9-10.2.C**
Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.

**CCSS.ELA-LITERACY.WHST.9-10.2.D**
Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.

**CCSS.ELA-LITERACY.WHST.9-10.2.E**
Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

**CCSS.ELA-LITERACY.WHST.9-10.2.F**
Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

**CCSS.ELA-LITERACY.WHST.9-10.3**
(See note; not applicable as a separate requirement)

**Production and Distribution of Writing:**

**CCSS.ELA-LITERACY.WHST.9-10.4**

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

**CCSS.ELA-LITERACY.WHST.9-10.5**

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

**CCSS.ELA-LITERACY.WHST.9-10.6**

Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

**Research to Build and Present Knowledge:**

**CCSS.ELA-LITERACY.WHST.9-10.7**

Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

**CCSS.ELA-LITERACY.WHST.9-10.8**

Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

**CCSS.ELA-LITERACY.WHST.9-10.9**

Draw evidence from informational texts to support analysis, reflection, and research.

**Range of Writing:**

**CCSS.ELA-LITERACY.WHST.9-10.10**

Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.