



North Carolina Department of Public Instruction

## **INSTRUCTIONAL SUPPORT TOOLS**

FOR ACHIEVING NEW STANDARDS

This document is designed to help North Carolina educators teach the Essential Standards (Standard Course of Study). NCDPI staff are continually updating and improving these tools to better serve teachers.

### *Essential Standards: Biology • Unpacked Content*

For the new Essential Standards that will be effective in all North Carolina schools in the 2012-13.

#### **What is the purpose of this document?**

To increase student achievement by ensuring educators understand specifically what the new standards mean a student must know, understand and be able to do.

#### **What is in the document?**

Descriptions of what each standard means a student will know, understand and be able to do. The “unpacking” of the standards done in this document is an effort to answer a simple question “What does this standard mean that a student must know and be able to do?” and to ensure the description is helpful, specific and comprehensive for educators.

#### **How do I send Feedback?**

We intend the explanations and examples in this document to be helpful and specific. That said, we believe that as this document is used, teachers and educators will find ways in which the unpacking can be improved and made ever more useful. Please send feedback to us at [feedback@dpi.state.nc.us](mailto:feedback@dpi.state.nc.us) and we will use your input to refine our unpacking of the standards. Thank You!

#### **Just want the standards alone?**

You can find the standards alone at <http://dpi.state.nc.us/acre/standards/new-standards/#science> .

Note on Numbering: **Bio**–Biology

# Structures and Functions of Living Organisms

## Essential Standard and Clarifying Objectives

### Bio.1.1 Understand the relationship between the structures and functions of cells and their organelles.

- Bio.1.1.1 Summarize the structure and function of organelles in eukaryotic cells (including the nucleus, plasma membrane, cell wall, mitochondria, vacuoles, chloroplasts, and ribosomes) and ways that these organelles interact with each other to perform the function of the cell.
- Bio.1.1.2 Compare prokaryotic and eukaryotic cells in terms of their general structures (plasma membrane and genetic material) and degree of complexity.
- Bio.1.1.3 Explain how instructions in DNA lead to cell differentiation and result in cells specialized to perform specific functions in multicellular organisms.

## Unpacking

What does this standards mean a child will know and be able to do?

### Bio.1.1.1

- Identify these cell organelles in diagrams of plant and animal cells. (middle school review)
- Explain how the structure of the organelle determines its function. (Example: folded inner membrane in mitochondria increases surface area for energy production during aerobic cellular respiration).
- Summarize how these organelles interact to carry out functions such as energy production and use, transport of molecules, disposal of waste, and synthesis of new molecules. (Example: DNA codes for proteins which are assembled by the ribosomes and used as enzymes for energy production at the mitochondria).

### Bio.1.1.2

- Proficiently use proper light microscopic techniques as well as determine total power magnification. The purpose is to use microscopes to observe a variety of cells with particular emphasis on the differences between prokaryotic and eukaryotic as well as plant and animal cells. While students are not expected to understand how scanning and electron transmission microscopes work, they should recognize that they reveal greater detail about eukaryotic and prokaryotic cell differences.
- Infer that prokaryotic cells are less complex than eukaryotic cells.
- Compare the structure of prokaryotic and eukaryotic cells to conclude the following:
  - Presence of membrane bound organelles – mitochondria, nucleus, vacuole, and chloroplasts are not present in prokaryotes.

- Ribosomes are found in both.
- DNA and RNA are present in both, but are not enclosed by a membrane in prokaryotes.
- Contrasts in chromosome structure – circular DNA strands called plasmids are characteristic of prokaryotes.
- Contrasts in size – prokaryotic cells are smaller.

### Bio.1.1.3

- Compare a variety of specialized cells and understand how the functions of these cells vary. (Possible examples could include nerve cells, muscle cells, blood cells, and sperm cells.)
- Explain that multicellular organisms begin as undifferentiated masses of cells and that variation in DNA expression and gene activity determines the differentiation of cells and ultimately their specialization.
  - During the process of differentiation, only specific parts of the DNA are activated; the parts of the DNA that are activated determine the function and specialized structure of a cell.
  - Because all cells contain the same DNA, all cells initially have the potential to become any type of cell; however, once a cell differentiates, the process cannot be reversed.
  - Nearly all of the cells of a multicellular organism have exactly the same chromosomes and DNA.
  - Different parts of the genetic instructions are used in different types of cells, influenced by the cell's environment and past history.
- Recall that chemical signals may be released by one cell to influence the development and activity of another cell.
- Identify stem cells as unspecialized cells that continually reproduce themselves and have, under appropriate conditions, the ability to differentiate into one or more types of specialized cells.
  - Embryonic cells which have not yet differentiated into various cell types are called embryonic stem cells.
  - Stem cells found in organisms, for instance in bone marrow, are called adult stem cells.
  - Scientists have recently demonstrated that stem cells, both embryonic and adult, with the right laboratory culture conditions, differentiate into specialized cells.

**Note:** *It is not essential for students to understand the details of how the process of transcriptional regulation in a cell produces specific proteins which results in cell differentiation.*

## Essential Standard and Clarifying Objectives

### Bio.1.2 Analyze the cell as a living system.

Bio.1.2.1 Explain how homeostasis is maintained in a cell and within an organism in various environments (including temperature and pH).

Bio.1.2.2 Analyze how cells grow and reproduce in terms of interphase, mitosis and cytokinesis.

Bio.1.2.3 Explain how specific cell adaptations help cells survive in particular environments (focus on unicellular organisms).

## Unpacking

What does this standards mean a child will know and be able to do?

### Bio.1.2.1

- Explain how cells use buffers to regulate cell pH and how cells can respond to maintain temperature, glucose levels, and water balance in organisms.
- Compare the mechanisms of active vs. passive transport (diffusion and osmosis).
- Conclude how the plasma membrane structure functions.
- Explain changes in osmotic pressure that occurs when cells are placed in solutions of differing concentrations.

### Bio.1.2.2

- Outline the cell cycle – Growth1, Synthesis, Growth2, Mitosis, and Cytokinesis.
- Recognize mitosis as a part of asexual reproduction. (middle school review)
- Organize diagrams of mitotic phases and describe what is occurring throughout the process.

**Note:** *When students learn about meiosis (Bio.3.2.1), they should compare it to the process of mitosis.*

### Bio.1.2.3

- Explain how various structures of unicellular organisms help that organism survive. Emphasis is on contractile vacuoles, cilia, flagella, pseudopods, and eyespots.
- Summarize adaptive behaviors – examples include chemotaxis and phototaxis.

# Ecosystems

## Essential Standard and Clarifying Objectives

### Bio.2.1 Analyze the interdependence of living organisms within their environments.

Bio.2.1.1 Analyze the flow of energy and cycling of matter (such as water, carbon, nitrogen and oxygen) through ecosystems relating the significance of each to maintaining the health and sustainability of an ecosystem.

Bio.2.1.2 Analyze the survival and reproductive success of organisms in terms of behavioral, structural, and reproductive adaptations.

Bio 2.1.3 Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within ecosystems.

Bio.2.1.4 Explain why ecosystems can be relatively stable over hundreds or thousands of years, even though populations may fluctuate (emphasizing availability of food, availability of shelter, number of predators and disease).

## Unpacking

What does this standards mean a child will know and be able to do?

### Bio.2.1.1

- Deconstruct the carbon cycle as it relates to photosynthesis, cellular respiration, decomposition and climate change.
- Summarize the nitrogen cycle (including the role of nitrogen fixing bacteria) and its importance to synthesis of proteins and DNA.
- Identify factors that influence climate such as:
  - greenhouse effect (relate to carbon cycle and human impact on atmospheric CO<sub>2</sub>)
  - natural environmental processes (relate to volcanic eruption and other geological processes)
- Explain the recycling of matter within ecosystems and the tendency toward a more disorganized state.
- Analyze energy pyramids for direction and efficiency of energy transfer.
  - Living systems require a continuous input of energy to maintain organization. The input of radiant energy which is converted to chemical energy allows organisms to carry out life processes.
  - Within ecosystems energy flows from the radiant energy of the sun through producers and consumers as chemical energy that is ultimately transformed into heat energy. Continual refueling of radiant energy is required by ecosystems.

## Bio 2.1.2

**Note:** *The focus has moved away from an exhaustive study of classes of living things through comparative anatomy to emphasizing connections between organisms' adaptations (behavioral, structural, and reproductive) and survival in their particular environment.*

- Analyze how various organisms accomplish life functions through adaptations within particular environments (example: water or land) to ensure survival and reproductive success.
- Relate prior understanding of survival and reproductive success to evidence of variations observed in species in three areas:
  - ***behavioral adaptations*** – suckling, taxes/taxis, migration, estivation, hibernation, habituation, imprinting, classical conditional, and trial and error learning
  - ***structural adaptations***–nutrition, respiration, transport and excretion mechanisms, camouflage, movement
  - ***reproductive adaptations***– sexual versus asexual, eggs, seeds, spores, placental, types of fertilization.

## Bio 2.1.3

- Identify and describe symbiotic relationships such as mutualism and parasitism. (middle school review)
- Exemplify various forms of communication and territorial defense including communication within social structure using pheromones (Examples: bees, ants, termites), courtship dances, territorial defense (Example: fighting fish).
- Explain patterns in predator /prey and competition relationships and how these patterns help maintain stability within an ecosystem with a focus on population dynamics.

**Note:** *There is much debate about whether commensalistic relationships are just early mutualism. We may just not understand the benefits to each organism.*

## Bio.2.1.4

- Generalizing that although some populations have the capacity for exponential growth, there are limited resources that create specific carrying capacities and population sizes are in a dynamic equilibrium with these factors. (e.g. food availability, climate, water, territory).
- Interpret various types of population graphs – human population growth graphs indicating historical and potential changes, factors influencing birth rates and death rates, and effects of population size, density and resource use on the environment.
- Explain how disease can disrupt ecosystem balance. (Examples: AIDS, influenza, tuberculosis, Dutch Elm Disease, Pfiesteria, etc.)

## Essential Standard and Clarifying Objectives

### **Bio.2.2 Understand the impact of human activities on the environment (one generation affects the next).**

Bio.2.2.1 Infer how human activities (including population growth, pollution, global warming, burning of fossil fuels, habitat destruction and introduction of nonnative species) may impact the environment.

Bio.2.2.2 Explain how the use, protection and conservation of natural resources by humans impact the environment from one generation to the next.

## Unpacking

What does this standards mean a child will know and be able to do?

### Bio.2.2.1

- Summarize how humans modify ecosystems through population growth, technology, consumption of resources and production of waste.
- Interpret data regarding the historical and predicted impact on ecosystems and global climate.
- Explain factors that impact North Carolina ecosystems. (Examples: acid rain effects in mountains, beach erosion, urban development in the Piedmont leading to habitat destruction and water runoff, waste lagoons on hog farms, Kudzu as an invasive plant, etc.).

### Bio.2.2.2

- Explain the impact of humans on natural resources (e.g. resource depletion, deforestation, pesticide use and bioaccumulation )
- Exemplify conservation methods and stewardship.

## Evolution and Genetics

### Essential Standard and Clarifying Objectives

#### Bio.3.1 Explain how traits are determined by the structure and function of DNA.

Bio.3.1.1 Explain the double-stranded, complementary nature of DNA as related to its function in the cell.

Bio.3.1.2 Explain how DNA and RNA code for proteins and determine traits.

Bio.3.1.3 Explain how mutations in DNA that result from interactions with the environment (i.e. radiation and chemicals) or new combinations in existing genes lead to changes in function and phenotype.

### Unpacking

What does this standards mean a child will know and be able to do?

#### Bio.3.1.1

- Develop a cause-and-effect model relating the structure of DNA to the functions of replication and protein synthesis:
  - The structure of DNA is a double helix or “twisted ladder” structure. The sides are composed of alternating phosphate-sugar groups and “rungs of the DNA ladder” are composed of complementary nitrogenous base pairs (always adenine, A, to thymine, T, and cytosine, C, to guanine, G) joined by weak hydrogen bonds.
  - The sequence of nucleotides in DNA codes for proteins which is central key to cell function and life.
  - Replication occurs during the S phase of the cell cycle and allows daughter cells to have an exact copy of parental DNA.
  - Cells respond to their environments by producing different types and amounts of protein.
  - With few exceptions, all cells of an organism have the same DNA but differ based on the expression of genes.
- Infer the advantages (injury repair) and disadvantages (cancer) of the overproduction, underproduction or production of proteins at the incorrect times.

#### Bio.3.1.2

- Explain the process of protein synthesis:
  - Transcription that produces an RNA copy of DNA
  - mRNA traveling to the ribosome (rRNA)
  - Translation – tRNA supplies appropriate amino acids



- Amino acids are linked by peptide bonds to form polypeptides. Polypeptide chains form protein molecules. Proteins can be structural (forming a part of the cell materials) or functional (hormones, enzymes, or chemicals involved in cell chemistry).
- Interpret a codon chart to determine the amino acid sequence produced by a particular sequence of bases.
- Explain how an amino acid sequence forms a protein that leads to a particular function and phenotype (trait) in an organism.

#### Bio.3.1.3

- Understand that mutations are changes in DNA coding and can be deletions, additions, or substitutions. Mutations can be random and spontaneous or caused by radiation and/or chemical exposure.
- Develop a cause and effect model in order to describe how mutations change amino acid sequence, protein function, and phenotype. Only mutations in sex cells (egg and sperm) or in the gamete produced from the primary sex cells can result in heritable changes.

### Essential Standard and Clarifying Objectives

#### **Bio.3.2 Understand how the environment, and/or the interaction of alleles, influences the expression of genetic traits.**

Bio.3.2.1 Explain the role of meiosis in sexual reproduction and genetic variation.

Bio.3.2.2 Predict offspring ratios based on a variety of inheritance patterns (including dominance, co-dominance, incomplete dominance, multiple alleles, and sex-linked traits).

Bio.3.2.3 Explain how the environment can influence the expression of genetic traits.

### Unpacking

What does this standards mean a child will know and be able to do?

#### Bio.3.2.1

- Recall the process of meiosis and identify process occurring in diagrams of stages. (middle school review) Note: *Students are not expected to memorize the names of the steps or the order of the step names.*
- Infer the importance of the genes being on separate chromosomes as it relates to meiosis.
- Explain how the process of meiosis leads to independent assortment and ultimately to greater genetic diversity.
- Exemplify sources of genetic variation in sexually reproducing organisms including crossing over, random assortment of chromosomes, gene mutation, nondisjunction, and fertilization.
- Compare meiosis and mitosis including type of reproduction (asexual or sexual), replication and separation of DNA and cellular

material, changes in chromosome number, number of cell divisions, and number of cells produced in a complete cycle.

#### Bio.3.2.2

- Interpret Punnett squares (**monohybrid only**) to determine genotypic and phenotypic ratios. Understand that dominant alleles mask recessive alleles.
- Determine parental genotypes based on offspring ratios.
- Interpret karyotypes (gender, and chromosomal abnormalities).
- Recognize a variety of intermediate patterns of inheritance (codominance and incomplete dominance).
- Recognize that some traits are controlled by more than one pair of genes and that this pattern of inheritance is identified by the presence of a wide range of phenotypes (skin, hair, and eye color).
- Interpret autosomal inheritance patterns: sickle cell anemia including the relationship to malaria, cystic fibrosis (recessive heredity), and Huntington's disease (dominant heredity).
- Solve and interpret codominant crosses involving multiple alleles including blood typing problems. (Blood Types: A, B, AB and O and Alleles:  $I^A$ ,  $I^B$ , and  $i$ ). Students should be able to determine if parentage is possible based on blood types.
- Understand human sex chromosomes and interpret crosses involving sex-linked traits (color-blindness and hemophilia). Students should understand why males are more likely to express a sex-linked trait.
- Interpret phenotype pedigrees to identify the genotypes of individuals and the type of inheritance.

#### Bio.3.2.3

Develop a cause-and-effect relationship between environmental factors and expression of a particular genetic trait. All traits depend both on genetic and environmental factors. Heredity and environment interact to produce their effects. This means that the way genes are expressed depends on the environment in which they act.

### Essential Standard and Clarifying Objectives

#### Bio.3.3 Understand the application of DNA technology.

Bio.3.3.1 Interpret how DNA is used for comparison and identification of organisms.

Bio.3.3.2 Summarize how transgenic organisms are engineered to benefit society.

Bio.3.3.3 Evaluate some of the ethical issues surrounding the use of DNA technology (including cloning, genetically modified organisms, stem cell research, and Human Genome Project).

## Unpacking

What does this standards mean a child will know and be able to do?

### Bio.3.3.1

- Summarize the process of gel electrophoresis as a technique to separate molecules based on size. Students should learn the general steps of gel electrophoresis – using restrictions enzymes to cut DNA into different sized fragments and running those fragments on gels with longer fragments moving slower than faster ones.
- Interpret or “read” a gel.
- Exemplify applications of DNA fingerprinting - identifying individuals; identifying and cataloging endangered species.

### Bio.3.3.2

- Generalize the applications of transgenic organisms (plants, animals, & bacteria) in agriculture and industry including pharmaceutical applications such as the production of human insulin.
- Summarize the steps in bacterial transformation (insertion of a gene into a bacterial plasmid, getting bacteria to take in the plasmid, selecting the transformed bacteria, and producing the product).

### Bio.3.3.3

- Identify the reasons for establishing the Human Genome Project.
- Recognize that the project is useful in determining whether individuals may carry genes for genetic conditions and in developing gene therapy.
- Evaluate some of the science of gene therapy. (e.g. Severe Combined Immunodeficiency and Cystic Fibrosis)
- Critique the ethical issues and implications of genomics and biotechnology (stem cell research, gene therapy and genetically modified organisms).

## Essential Standard and Clarifying Objectives

### **Bio.3.4 Explain the theory of evolution by natural selection as a mechanism for how species change over time.**

Bio.3.4.1 Explain how fossil, biochemical, and anatomical evidence support the theory of evolution.

Bio.3.4.2 Explain how natural selection influences the changes in species over time.

Bio.3.4.3 Explain how various disease agents (bacteria, viruses, chemicals) can influence natural selection.

## Unpacking

What does this standards mean a child will know and be able to do?

### Bio.3.4.1

- Summarize the hypothesized early atmosphere and experiments that suggest how the first “cells” may have evolved and how early conditions affected the type of organism that developed (first anaerobic and prokaryotic, then photosynthetic, then eukaryotic, then multicellular).
- Summarize how fossil evidence informs our understanding of the evolution of species and what can be inferred from this evidence.
- Generalize what biochemical (molecular) similarities tell us about evolution.
- Generalize what shared anatomical structures (homologies) tell us about evolution.

### Bio.3.4.2

- Develop a cause and effect model for the process of natural selection:
  - Species have the potential to increase in numbers exponentially.
  - Populations are genetically variable due to mutations and genetic recombination.
  - There is a finite supply of resources required for life.
  - Changing environments select for specific genetic phenotypes.
  - Those organisms with favorable adaptations survive, reproduce and pass on their alleles.
  - The accumulation and change in favored alleles leads to changes in species over time.
- Illustrate the role of geographic isolation in speciation.

### Bio.3.4.3

Develop a cause and effect model for the role of disease agents in natural selection including evolutionary selection of resistance to antibiotics and pesticides in various species, passive/active immunity, antivirals and vaccines.

## Essential Standard and Clarifying Objectives

### **Bio.3.5 Analyze how classification systems are developed upon speciation.**

Bio.3.5.1 Explain the historical development and changing nature of classification systems.

Bio.3.5.2 Analyze the classification of organisms according to their evolutionary relationships (including dichotomous keys and phylogenetic trees).

## Unpacking

What does this standards mean a child will know and be able to do?

### Bio.3.5.1

- Generalize the changing nature of classification based on new knowledge generated by research on evolutionary relationships and the history of classification system.

### Bio.3.5.2

- Classify organisms using a dichotomous key.
- Compare organisms on a phylogenetic tree in terms of relatedness and time of appearance in geologic history.

## Molecular Biology

### Essential Standard and Clarifying Objectives

#### Bio.4.1 Understand how biological molecules are essential to the survival of living organisms.

Bio.4.1.1 Compare the structures and functions of the major biological molecules (carbohydrates, proteins, lipids, and nucleic acids) as related to the survival of living organisms.

Bio.4.1.2 Summarize the relationship among DNA, proteins and amino acids in carrying out the work of cells and how this is similar in all organisms.

Bio.4.1.3 Explain how enzymes act as catalysts for biological reactions.

### Unpacking

What does this standards mean a child will know and be able to do?

#### Bio.4.1.1

Compare the structure and function of each of the listed organic molecules in organisms:

- Carbohydrates (glucose, cellulose, starch, glycogen)
- Proteins (insulin, enzymes, hemoglobin)
- Lipids (phospholipids, steroids)
- Nucleic Acids (DNA, RNA)

#### Bio.4.1.2

- Recall that the sequence of nucleotides in DNA codes for specific amino acids which link to form proteins.
- Identify the five nitrogenous bases (A, T, C, G and U) found in nucleic acids as the same for all organisms.
- Summarize the process of protein synthesis.

**Note:** Students are not expected to memorize the names and/or structures or characteristics of the 20 amino acids. The focus should be on the fact that side chains are what make each of the amino acids different and determine how they bond and fold in proteins. (Relate to Bio.3.1.2)

## Bio.4.1.3

- Develop a cause and effect model for specificity of enzymes - the folding produces a 3-D shape that is linked to the protein function, enzymes are proteins that speed up chemical reactions (catalysts) by lowering the activation energy, are re-usable and specific, and are affected by such factors as pH and temperature.

**Note:** *Students should understand that enzymes are necessary for all biochemical reactions and have a general understanding of how enzymes work in terms of the connection between shape and function.*

## Essential Standard and Clarifying Objectives

### Bio.4.2 Analyze the relationships between biochemical processes and energy use in the cell.

Bio.4.2.1 Analyze photosynthesis and cellular respiration in terms of how energy is stored, released, and transferred within and between these systems.

Bio 4.2.2 Explain ways that organisms use released energy for maintaining homeostasis (active transport).

## Unpacking

What does this standards mean a child will know and be able to do?

## Bio.4.2.1

- Analyze overall reactions including reactants and products for photosynthesis and cellular respiration and factors which affect their rates (amounts of reactants, temperature, pH, light, etc.).
- Compare these processes with regard to efficiency of ATP formation, the types of organisms using these processes, and the organelles involved. (Anaerobic respiration should include lactic acid and alcoholic fermentation.)

**Note:** *(1) Instruction should include the comparison of anaerobic and aerobic organisms. (2) Glycolysis, Kreb's Cycle, and Electron Transport Chain are not addressed.*

## Bio 4.2.2

Conclude that energy production by organisms is vital for maintaining homeostasis and that maintenance of homeostasis is necessary for life. Examples: Active transport of needed molecules or to rid the cell of toxins; movement to avoid danger or to find food, water, and or mates; synthesizing needed molecules.