OKLAHOMA ACADEMIC STANDARDS

SCIENCE
FRAMEWORK
BIOLOGY: OVERVIEW

OKLAHOMA STATE DEPARTMENT OF EDUCATION
CHAMPION EXCELLENCE

The Oklahoma State Department of Education is excited to announce the release of the first resources being offered through the Oklahoma Academic Standards Science Frameworks. The Science Frameworks represent curricular resources developed by Oklahoma teachers to help teachers translate standards into classroom practice. The *Framework Overviews* represent how a group of Oklahoma teachers, at a given grade level, might bundle performance expectations/standards found in the Oklahoma Academic Standards for Science.[1] **Bundling** is how teachers would **group performance expectations/standards** for the purpose of developing **instructional units of study.**

Once bundled, the *Science Framework* writers were then charged with completing **four categories of information** that coincided with the bundle of performance expectations/standards. The categories provide insight into how the Science Framework writers collaborated to begin to translate standards into classroom instruction. The guidance provided in the categories does **not** represent a **directive** to teachers, schools or districts for classroom instruction and should not be viewed as such.

The Oklahoma State Department of Education would like to say a special thank you to the Oklahoma educators who participated in developing the Oklahoma Science Framework Overviews, Doug Paulson of the Minnesota State Department of Education who served as a consultant, Lawton Public Schools and to Quentin Biddy, the project director.

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> "The vision of the Overviews is to provide a resource for teachers that encourages them to embrace the new standards and implement them effectively in their classrooms. The suggestions provided by the frameworks project **do not** have to be implemented exactly as they are written and are **not required** to be a successful teacher, but **serve as a guide** to setting up effective lessons that will help students meet the necessary levels of success in a science classroom." - Oklahoma Science Framework Project Writer

[1] Download the Oklahoma Academic Standards for Science at http://sde.ok.gov/sde/science.

How To Read This Document

Below you will find short descriptions about each of the sections of information provided in this document. If you have questions regarding the *Framework Overviews*, please contact Tiffany Neill at 405-522-3524 or Tiffany.Neill@sde.ok.gov

Science Framework Overview: Sections

In Lay Terms

This section aims at providing a brief introduction to the goals outlined in the Performance Expectation Bundles/grouping of standards.

Three Dimensional Storyline

This section aims at providing a comprehensive instructional storyline of how the three dimensions represented in the Performance Expectation Bundles intertwine to support students engaging in science and engineering practices, crosscutting concepts and disciplinary core ideas. Keep in mind each performance expectation includes one **science and engineering practice**, one **crosscutting concept** and one **disciplinary core idea**. The **color-coding** in this section allows teachers to see where components of these three dimensions appear in the instructional storyline. To find out more about the three dimensions and how they are incorporated into the Oklahoma Academic Standards for Science, review pages 7-8 in the Oklahoma Academic Standards for Science[2] or check out the OKSci PD on Your Plan Module series, Transitioning to the Oklahoma Academic Standards for Science[3].

Lesson Level Performance Expectations

This section aims at providing **scaffolding three-dimensional learning targets** that teachers can design instruction around to meet the end goals of the Performance Expectation(s) represented in the bundles or units of study. Keep in mind the performance expectations represent the things students should know, understand and be able to do to show proficiency at the end of instruction they participate in. A teacher can **utilize** the **Lesson Level Performance Expectations** in each bundle **as a way to develop a series of instruction** to meet the end goals of the performance expectations. For example, a teacher can develop or use a lesson, which may allow students to participate in instruction that covers some of the Lesson Level Performance Expectations, but not all. In this case the teacher would then develop or conduct another lesson that covers other Lesson Level Performance Expectations in the bundle.

Misconceptions

This section aims at providing research-based misconceptions that students frequently have related to the science concepts (disciplinary core ideas) embedded in the Performance Expectation Bundles along with matching correct conceptions.

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[2] Download the Oklahoma Academic Standards for Science at http://sde.ok.gov/sde/science.

[3] Access the OKSci PD on Your Plan Modules at: https://www.evernote.com/l/AUXXlQC11VZDeLmUkOMPpjhKeJjqS-R8gww

Bundle: Adaptations

HS-LS2-8

Students who demonstrate understanding can:

Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

HS-LS4-4

Students who demonstrate understanding can:

Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5

Students who demonstrate understanding can:

Synthesize, communicate, and evaluate the information that describes how changes in the environmental conditions can affect the distribution of traits in a population causing: 1) increases in the number of individuals of some species, 2) the emergence of new species over time, and 3) the extinction of other species.

In Lay Terms

Over the course of time, species with traits or characteristics that are better suited for them to survive in a habitat, are likely to have more success than those that have traits or characteristics that are less suited to a habitat. When an organism has a trait that makes it better suited to the environment, it is called an adaptation. An adaptation is a mutation, or genetic change, that helps an organism, such as a plant or animal, survive in its environment. Due to the helpful nature of the mutation, it is passed down from one generation to the next. As more and more organisms inherit the mutation, the mutation becomes more prevalent in the population. The mutation has become an adaptation. Adaptive traits can be physical or behavioral. Social or group behaviors often develop in populations as a way to overcome limiting factors. For example, herding behavior has developed in many prey species. Herding increases the chance of the individual animal to survive a predator's attack and has thus developed as an adaptation to predators in their environment.

Three Dimensional Storyline

Adaptation is the primary mechanism by which changes in biodiversity occur. In this bundle of performance expectations, students can engage in investigations and generate evidence to defend and critique claims for how changes in genetic diversity can affect the increase or decrease of populations and emergence or extinction of species. Using simulations, data sets and/or case studies, students can construct explanations about how different environmental conditions affect populations. Those organisms that are anatomically, behaviorally, and physiologically well suited to a specific environment will survive and reproduce. Through synthesis of this information students can engage in argument from evidence about the origins of adaptations and predict their effects on survival and reproduction. In order to truly understand adaptations, students must first

understand the cause and effect relationship between change in genetic frequency and overall reproduction or survival success in a population.

Through analyzing evidence students can understand how the selection of beneficial traits (natural selection) causes adaptations in population. Because these adaptations have the effect of increasing an individual's ability to survive and reproduce, the gene for the beneficial trait may increase and thus alter the genetic frequency of that trait in the population. Students can investigate examples of grouping behaviors and cooperative behaviors and their effect on survival and reproduction.

Students can also use evidence to engage in argumentation, predicting how changes in environmental conditions (such as habitat destruction, invasive species etc.) can affect fitness of the population, which can lead to changes in biodiversity. Students can evaluate the connections between selection pressures, adaptations, and populations in order to analyze and communicate the changes in biodiversity on earth.

Lesson level Performance Expectations

- Students can synthesize, communicate and evaluate claims that changes in environmental conditions will affect survival strategies of populations.
- Students can construct an explanation based on evidence for how an adaptation leads to differential survival and reproduction of organisms.
- Students can analyze evidence to predict how changes in gene frequency within a population can alter its survival and reproduction.
- Students can evaluate evidence to predict how changes in environmental conditions will affect the fitness of a species.
- Students can synthesize, evaluate and communicate how selection pressures, adaptations can affect biodiversity on earth.
- Students can evaluate evidence to analyze the role of group behaviors in the ability of a species to survive and reproduce.

Misconceptions

1. Adaptations occur due to individual needs.
2. In all selection, fitness is a function of the bigger and stronger organisms.
3. That all members of a species are very similar and there is little variation within species or populations.
4. Students misunderstand the meaning of the terms "Adapt" and "Fitness".
5. Students do not see the link between genetic variation and adaptation.

Accurate Concept

1. Changes in the frequency of traits occur over generations as a result of environmental forces.
2. In natural selection, organisms that are best suited (not just bigger or stronger) for the current environmental conditions will survive and reproduce.
3. Variation exists across a single species.
4. In natural selection organisms that are best suited (not just bigger or stronger) for the current environmental conditions will survive and reproduce.
5. Genetic variations in a population result in some organisms having more advantageous traits.

References

- http://www.tandfonline.com/doi/abs/10.1080/00958964.1994.9941962#.VPpv-uEpvm4
- http://life.bio.sunysb.edu/~spgp/2004_02_10/Alters_and_Nelson_2002.pdf

Bundle: Heredity

HS-LS3-2

Students who demonstrate understanding can:

Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

HS-LS3-3

Students who demonstrate understanding can:

Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

In Lay Terms

Characteristics of living things are often passed down from parents to offspring, but there are variations from offspring to parent leading to multiple sources of variation within populations. Variation in individuals can result from different combinations of the genetic material of parents. This is why most siblings do not look identical to each other or to their parents. Individual variation can also be caused by errors made while cells are copying genetic material (DNA). Cells have mechanisms to check for mistakes, but some mistakes go undetected or uncorrected, resulting in a change in the genetic material. Environmental factors, like temperature, ultraviolet light, and exposure to some chemicals, also cause individual variation. Factors that affect the variation of traits also affect the probability of traits occurring within a population. Statistics and probability can be used to predict the distribution of expressed traits in a population.

Three Dimensional Storyline

Genetic variation is essential to the continuation of life on earth. Through sexual reproduction genes are divided and recombined in a myriad of ways resulting in organisms that can adapt to a wide variety of environmental conditions. Some species reproduce sexually and offspring inherit different combinations of genetic information from their parents through the processes of meiosis and fertilization. Students can cite evidence from these processes explaining how and when they allow for genetic variation to occur (e.g. random assortment, nondisjunction, crossing over, etc.). Changes in genetic information can similarly arise from viable errors in replication, called mutations. These errors can cause huge changes in the expression of traits, or they may not cause any change in expression. Slight errors in genetic information can result in cascades of changes that students can trace to determine its effects at varying scales. Students can use this evidence to defend the cause and effect relationship that a change in an organism's DNA may impact an individual cell's functioning, the health of the organism, and ultimately the population as a whole if the change is passed on.

Within a species, individual variation is the result of both genetic factors and environmental conditions. Individuals in a species have similar DNA sequences, but they are not genetically identical. Students can make hypotheses about relatedness by analyzing DNA sequences using statistics

and probability. At this level, students are expected to predict the probability of inherited traits using simple Punnett squares. Students can also gather and analyze data to defend claims about changes in genetic variation at different levels with the use of pedigrees, karyotypes, and DNA sequences.

The expression and development of traits over many generations can also be influenced by external environmental factors. Because it is often difficult, if not impossible, for biologists to measure, students can use models to assess the effects of environmental changes in populations over various time frames and geographic scales. Students can then analyze the data collected from all of the models in this bundle to make predictions and defend claims explaining genetic changes and variation within populations.

Lesson Level Performance Expectations

- Students can use models to explain how meiosis leads to genetic variation.
- Students can construct explanations to describe how the process of DNA replication can lead to genetic variation.
- Students can construct explanations to describe how errors in DNA can cause alterations in gene expression in populations.
- Students can make and defend claims based on evidence about environmental factors that can interfere with DNA replication.
- Students can construct explanations to describe how mutations in genes are inherited.
- Students can analyze and interpret data to identify patterns in DNA expression.
- Students can plan and carry out investigations to test the effects of environmental factors affecting DNA expression in an individual organism (UV rays, radiation, nutrition, etc.) compared to entire populations (natural selection, sexual selection, competition, etc.).
- Students can use genetic models to predict the frequency of gene expression for individuals and populations.
- Students can construct explanations to describe the variation and distribution of traits based on genetic and environmental factors.

Misconceptions

1. The information in the DNA molecules of an organism does not affect the functions of an organism's cells, or that the information in the DNA molecules of an organism does not affect the physical characteristics of the organism.
2. The age at which an organism acquires an environmentally induced characteristic will affect whether the characteristic is passed on to its offspring. For example, if a father lost a finger as a child, he will pass the missing-finger trait to his children, but if he lost his finger as an adult he will not pass the missing-

Accurate Concept

1. DNA in molecules of organisms affects both the structure and function of the organism's cells.
2. Environmentally acquired traits are not passed from parent to offspring; however environmental effects to gametes may cause changes in offspring.
3. Genes are expressed as traits.

finger to his children.

3. Genes are traits. Students may incorrectly assume that these terms are synonymous.

References

- http://assessment.aaas.org/topics/RH#/,tabs-300/2

Bundle: Molecular Genetics

HS-LS1-1

Students who demonstrate understanding can:

Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

HS-LS3-1

Students who demonstrate understanding can:

Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS4-1

Students who demonstrate understanding can:

Analyze and evaluate how evidence such as similarities in DNA sequences, anatomical structures, and order of appearance of structures during embryological development contribute to the scientific explanation of biological diversity.

In Lay Terms

Molecules called DNA are the instructions that all living organisms use to create all of the characteristics and traits it possesses. Cellular structures use the DNA as instructions for expressing traits that are passed down from parents to offspring. Highly similar DNA sequences lead to anatomical similarities, while differences in DNA sequences contribute to the diversity of living things.

Three Dimensional Storyline

All living organisms have DNA which codes for the structures that help them carry out functions necessary for life. Within the DNA, short regions called genes, code for the sequence of amino acids, forming the structure of proteins. Proteins can be assembled in various forms to create structures with specific functions that make survival possible. For example, proteins can provide structural support for the cell, act as signal molecules, regulate cell activities, and also play a role in the overall performance of cells by acting as catalysts for essential chemical reactions. The structures created by proteins form specialized cells in organisms, help them to grow, reproduce, and carry out specific tasks.

Students can ask questions to clarify how the structure of DNA affects the traits expressed by the organism. Through student investigations, use of models, and/or simulations, students can collect evidence to support the idea that the structure of DNA determines the structure and function of proteins. Students should be able to use a variety of evidence to explain the relationship between a protein's structure, determined by DNA, and the specialized function(s) that these proteins carry out that help an organism survive. As a result of this bundle, students can communicate that an

organism's identifiable traits, therefore, are the result of the proteins being expressed at a given time by the cells that make up that organism.

An organism's genetic material is made up of pieces of DNA, called chromosomes. Students can ask questions and eventually construct an explanation that will lead them to conclude that parents contribute genetic information to their offspring. Students can accomplish this through the examination of DNA models and observations of similarities between sexually - producing parents and offspring, and identifying patterns in those similarities and differences. This combination of genetic information is a source of variation within species. The inherited genetic information also leads to similarities such as anatomical structures, embryological development, and DNA sequences in closely related organisms. Students should be able to construct an argument for biological diversity and/or relatedness patterns in genetic and anatomic structures as evidence.

Lesson Level Performance Expectations

- Students can construct an explanation based on evidence that specialized structures within an organism's cells facilitate the essential functions of life.
- Students can create an argument based on evidence that protein structures within a cell are beneficial to the essential functions carried out in the cell.
- Students can analyze and interpret data in order to determine that all cells contain genetic information in the form of DNA molecules.
- Students can plan and carry out investigations to determine the function of specific genes in cells.
- Students can develop and use a model to explain that genes code for the formation of proteins and their specific structures.
- Students can develop models to represent the relationships between chromosomes, genes, and DNA.
- Students can construct a model such as Punnett squares, pedigrees, and karyotypes to make and defend a claim that the instructions for expressing a species' characteristic traits are carried in DNA.
- Students can construct explanations for how the same set of DNA in each cell may be regulated/expressed in different ways within an organism to construct cells and cell components of varying structure and function.
- Students can engage in argumentation from evidence to determine that some DNA codes for a variety of functions, such as proteins, regulatory or structural and some DNA segments code for functions that are not yet known.
- Students can apply scientific reasoning and models to determine that even though DNA sequences vary among species, there are also many overlaps.
- Students can use valid evidence, from a variety of sources, to explain the patterns that exists between overlapping DNA sequences from different species.
- Students can analyze the patterns found when comparing DNA sequences from different species to make inferences about the ongoing branching that produces multiple lines of descent that those species share.
- Students can analyze and interpret data from the similarities and differences in amino acid sequences and from anatomical and embryological evidence to make inferences about the multiple lines of descent that those species share.

Misconceptions	Accurate Concept
1. The information in the DNA molecules of an organism does not affect the organism's behavior or physical characteristics. 2. Students may confuse the subunits of each of DNA and protein molecules. DNA is composed of different combinations of four nucleic acids.	1. Genetic information is encoded in DNA molecules. This information influences an organism's physical traits and behavior. 2. Proteins are made up of amino acids, the sequence of which is determined by the organism's DNA sequence.

References

- http://assessment.aaas.org/topics/RH#/,tabs-300/2

Bundle: Natural Selection

HS-LS4-1

Students who demonstrate understanding can:

Analyze and evaluate how evidence such as similarities in DNA sequences, anatomical structures, and order of appearance of structures during embryonic development contribute to the scientific explanation of biological diversity

HS-LS4-2

Students who demonstrate understanding can:

Construct and explanation based on evidence that biological diversity is influenced by (1) the potential for a species to increase in number (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction (3) competition for limited resources (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

HS-LS4-3

Students who demonstrate understanding can:

Apply concepts of statistics and probability to support explanations that organisms with advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

In Lay Terms

All living organisms on earth show tremendous differences of form and function. Despite this diversity, all organisms share certain characteristics that distinguish them from non-living things. Within populations, small modifications occur at the genetic level (in DNA) with each generation, and these genetic changes can affect how the organism interacts with its environment. Over time, accumulation of these genetic changes can alter the characteristics of the whole population, and a new species appears. Major changes in life forms take place by the same mechanism, but over even longer periods of time.

Three Dimensional Storyline

. In this performance bundle, students can analyze evidence that heritable biological traits become either more or less common in a population through the process of natural selection. Students should understand that in order for natural selection to occur, there must be genetic variation within a population and that variation affects the survival and reproductive success of individuals in the population. In order to understand natural selection, students have to analyze evidence in order to explain that DNA sequences, anatomical structure, and embryonic development cause biological diversity. Biological diversity occurs because the inheritance of certain traits can lead to a competitive advantage for certain organisms in a given population. This competitive advantage is selected for causing increased survival and/or reproductive rates within the specific

populations. This selection causes shifts in the frequency of traits within a population over time. Students then construct explanations for how the increase in advantageous heritable traits affects the genetic variation in the population.

Changes in genetic variation affect overall changes in the proportion of certain genes in the population. Students will need to analyze how changes in biodiversity occur due to selection pressures that can limit or increase the reproductive success of the individual. Students can analyze data patterns that describe the inheritance of genes and explain how inheritance influences past and present biodiversity. In understanding these changes students will construct explanations of how changes in genetic diversity can affect the increase or decrease of populations and emergence or extinction of species. All of these changes affect the biodiversity of life on earth.

To assist students in their understanding of these concepts and ideas they must be able to apply concepts of probability and statistics to support explanations about the influence of inherited traits on populations. Students will then analyze and evaluate how that evidence contributes to explanations about patterns in natural selection. Students will then construct explanations based on that evidence, about the effect of natural selection on the biodiversity of life on earth.

Lesson Level Performance Expectations

- Students can analyze and evaluate how evidence of DNA and amino acid sequences vary among species.
- Students can analyze and evaluate how information from DNA and amino acid sequences is conserved despite the variation among species and leads to patterns in the genetics of organisms.
- Students can analyze data to support explanations to show patterns of similarities and differences in genetics, anatomical and embryonic development between species.
- Students can construct explanations based on evidence that conserved traits between and within species contribute to the scientific explanation of the mechanism of biodiversity.
- Students can apply concepts of statistics and probability to support explanations that specific traits affect individuals and give a competitive advantage.
- Students can construct an explanation based on evidence that individuals that have a competitive advantage can survive and reproduce at a higher rate.
- Students can construct explanations based on evidence that DNA and amino acid sequences cause physiological differences that affect organismal survival.
- Students can construct and explanations based on evidence that over time differential survival and reproduction can lead to natural selection.
- Students can construct explanations using data that when conditions change the distribution of traits in a population is also affected.

Misconceptions	Accurate Concept

1. Students believe change happens as a result of need or desire.
2. Students believe change has always occurred and always will occur.
3. Students believe traits that are used are retained and those traits that are not used are lost.
4. Students believe selection only occurs when organisms die.
5. Students believe all organisms in a species are essentially alike.
6. Students believe evolution equals speciation.

1. Changes in the frequency of traits occurs over generations as a result of environmental forces.
2. Changes in the frequency of traits occur at different rates, at different times depending on the environmental pressures.
3. Environmentally acquired traits are not passed from parent to offspring; however environmental effects to gametes may cause changes in offspring.
4. Selection is related to both survival and reproduction success.
5. Variation exists across a single species.
6. Evolution through natural selection can sometimes, but not always lead to speciation.

References

- http://www.montana.edu/kalinowski/KalinowskiReprints/2011_Andrews_et_al_AreHumandEvolving_EvoEduOutreach.pdf

Bundle: Cellular Systems

HS-LS1-2

Students who demonstrate understanding can:

Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3

Students who demonstrate understanding can:

Plan and conduct an investigation to provide evidence of the importance of maintaining homeostasis in living organisms.

HS-LS1-4

Students who demonstrate understanding can:

Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

In Lay Terms

Cells are the smallest unit of life. Each cell has a specific structure and function. Cells work together to carry out more and more complex functions in order to sustain life. These cells may be organized into larger structures or systems beginning with tissues and increasing in size and complexity to maintain organs, organ-systems, and eventually an organism. These structures can maintain balance (homeostasis) within an organism to ensure their survival. These structures are all dependent upon one another and any change within one structure can affect the functioning of other structures.

Three Dimensional Storyline

Cells are the smallest units of life on earth. All life begins from a single cell which must contain the genetic information to sustain organisms, varying from simple single-celled to complex multi-cellular organisms. Cells carry out specialized functions and form the basis of increasingly complex systems. These systems are continually responding to changes within an organism's internal and external environment to maintain homeostasis.

Each cell contains all of the genetic information necessary to sustain life. Students can analyze models of mitosis and meiosis, asexual and sexual reproduction, as well as cell specialization to support explanations the roles of these processes for sustaining life. Cells also serve as building blocks in all multicellular organisms that can be combined in a myriad of equally complex and efficient ways to form a hierarchical structural organization composed of: cells, tissues, organs, organ systems, and an organism as a whole. Students can develop and manipulate models to explain how these different levels of organization work together, discovering that each system is made up of numerous parts and are themselves

components of the next increasingly complex system.

All levels of the hierarchical structural organization of organisms work together to maintain homeostasis (balance within an organism), adapting to environmental changes both internally and externally. Students can develop and manipulate models of different systems to carry out investigations to answer questions about the effects of changing environmental conditions. Specific feedback mechanisms can be identified and tested at differing levels of organization including but not limited to: heart rate response to exercise, response of the stomata to moisture and temperature, root response to water levels, and cellular response to tonicity.

This concept bundle embraces two components that emphasize modeling, the crosscutting concept of "system and system models", and the science and engineering practice of "developing and using models". Together these components emphasize that students construct and use models to show understanding of systems (the cell, a group of cells, organs, and organ systems) and the parts in those system. In this bundle, the practice of modeling alongside the crosscutting concept of modeling can also be utilized by students to predict and show relationships between system components and other systems at different scales (i.e. Students can describe the structure of organelles, their functions, and how they fit together to sustain a cell. Students can alter environmental factors within a cell model and formulate predictions of how the cell will respond to maintain homeostasis and consequentially how these responses will affect the surrounding tissues, organs, and ultimately organism.

Lesson Level Performance Expectations

- Students can use modeling to explain the passing of genetic information via:
    - sexual and asexual reproduction
    - mitosis and meiosis
    - cell differentiation
- Students can produce models at different scales to display how the products of cellular division and differentiation create specialized systems.
- Students can use models to predict how changing environmental variables affect the development of different levels of organization within an organism.
- Students can develop models to simulate system interactions within organisms at the cellular, tissue, organ, organ-system, and organismal levels.
- Students can develop and manipulate a model to demonstrate how one system is made up of smaller systems and is itself a component of a larger system.
- Students can use models (mathematical, physical, conceptual, computer) to design and carry out experiments manipulating system components at differing levels of organization.
- Students can plan and carry out investigations manipulating various system components to determine the homeostatic responses of organisms to environmental changes.

- Students can produce evidence to predict and display how the feedback mechanisms within an organism respond to changing environmental variables.
- Students can construct an argument to explain that when environmental conditions are significantly outside an organism's normal tolerable range, that organisms may not be able to maintain homeostasis and cannot survive.

Misconceptions	Accurate Concept
1. All cells are the same size and shape. (CEM001) 2. There are no single - celled organisms. (CEM005) 3. Some living parts of organisms are not made of cells. (CEM003 4. Plants are not made of cells.(CEM004) 5. Cells of living organisms do not make molecules for their own growth and repair.(CEM056) 6. Cells do not eliminate their own wastes.(CEM051,CEM052,CEM050) 7. Cells do not carry out essential life functions for themselves. (CEM037) 8. In the early development of an organism, cells that result from cell division do not grow before dividing again. (CEM022) 9. Organisms grow by cell division, but cells do not themselves increase in size or mass. (CEM020) 10. In the early development of an organism, cells grow in size but the number of cells remains constant. (CEM023) 11. In the early development of an organism, the organism grows in size and mass without cell division or cell growth. (CEM024)	1-8. All living things are composed of one or more cells. 9-10. Cells in multicellular organisms repeatedly divide to make more cells for growth and repair.

References

- American Association for the Advancement of Science http://assessment.aaas.org/topics/CE#/

Bundle: Ecosystem Dynamics

HS-LS2-1

Students who demonstrate understanding can:

Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS- LS2-2

Students who demonstrate understanding can:

Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems in different scales.

HS-LS2-6

Students who demonstrate understanding can:

Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

In Lay Terms

Ecosystems are constantly changing. These changes can be a result of shifting living (predators, competition, and available food) and non-living (shelter, water, and climate) factors within a specific environment. Under most circumstances these factors ensure that a natural "balance" is maintained within a specific ecosystem. However, changes to one or more of these factors can result in an ecosystem breaking down or ultimately the creation of an entirely new ecosystem.

Three Dimensional Storyline

For every action in the natural world there is a reaction. In this performance bundle, students will discover that ecosystem interactions involve a myriad of components working with and sometimes against one another in a constantly changing world. These interactions can sustain stable ecosystems, create disturbances that affect other aspects of the environment, respond and recover from those disturbances, or cause ecosystem collapse or change in catastrophic situations.

Normally, ecosystems exist in a state of balance where organisms and resources remain relatively constant over time. Students can examine ecosystem simulations and interpret mathematical, graphical, and historical data of population changes over time. Using this data, students can establish and defend claims of what determines population limits (carrying capacity) over time. Students can evaluate the ecosystem components affecting populations at various scales, including lack of particular nutrients or disease at a cellular level, predator-prey relationships, competition,

and symbiosis at the organismal level, and natural disasters that may affect multiple ecosystems simultaneously. In evaluating patterns found in data students can determine that factors at varying orders of magnitude can impact one another even if those trends encompass areas that are too large or processes that are too slow to study directly. This emphasis on the "scale, proportion, and quantity" gives students the opportunity to accurately identify ecosystem components at various scales and allows them to identify "cause and effect" relationships between various factors. Once students can determine ecosystem inputs and outputs and their impact on one another, students can utilize graphical representations, mathematical modeling, and case studies - (averages, linear and exponential trends, carrying capacity) - to evaluate and predict future changes within an ecosystem.

Lesson Level Performance Expectations

- Students can analyze a set of data and mathematically model the carrying capacity of an ecosystem.
- Students can make a quantitative claim regarding an ecosystem's carrying capacity.
- Students can utilize a mathematical model to explain how an ecosystem's carrying capacity represents the limit of organisms and populations that, ecosystem can support.
- Students can determine factors (availability of living and nonliving resources, predation, competition, and disease) that influence the carrying capacity of an ecosystem.
- Students can construct an explanation for how factors influence the carrying capacity of an ecosystem.
- Students can use a mathematical model to support a claim that organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources have limits.
- Students can evaluate evidence to explain how a complex set of interactions within an ecosystem can keep the number and type of organisms relatively constant over long periods of time under stable conditions.
- Students can evaluate the claims, evidence, and/or reasoning behind an ecosystem's resilience if it undergoes a modest biological or physical disturbance.
- Students can construct an argument using evidence to explain that if an ecosystem undergoes a modest biological or physical disturbance it can be resilient and return to a relatively normal state.
- Students can make and defend a claim based on evidence for how extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat.

Misconceptions	Accurate Concept
1. If a population in a food web is disturbed, there will be little or no effect on populations that are not within the linear sequence in the food web.	1. All organisms, both land-based and aquatic, are connected to other organisms by their need for food. This results in a global network of interconnections, which is referred to as a food web. Changes to any one part of the food web can have varying effects on the entire food web.
2. Varying the size of a population of organisms will only affect those populations of organisms that are	2. All organisms are important within an ecosystem. Varying a species'

directly connected to it in a feeding relationship, not organisms that are one or more steps away from it.
3. If the size of one population in a food web is altered, all other populations in the web will be altered the same way.
4. Organisms higher in the food web eat everything that is lower in the food web.
5. Populations exist in states of either constant growth or decline.
6. Competition between organisms always involved direct, aggressive interaction. (Getting to the resource before other organisms is not competition).
7. Plants do not compete for resources
8. Organisms of the same species do not compete.
9. Plants and animals do not compete for space or water.
10. Animals do not compete for shelter.

population size may not affect all other species equally, but it will affect the ecosystem as a whole.
3. All organisms are important within an ecosystem. Varying a species' population size may not affect all other species equally, but it will affect the ecosystem as a whole.
4. Organisms higher in a food chain eat some, but not necessarily all, of the organisms below them in the food web.
5. Food webs most accurately depict the flow of energy within an ecosystem. They depict a complex set of relationships that are dynamic in nature.

6-10. In all environments, individual organisms that depend on the same resource may compete for that resource when it is limited. Resources that can be limited include food, space, water, shelter, and light.

References

- American Association for the Advancement of Science http://assessment.aaas.org/topics/IE#/,tabs-176/2

Bundle: Cycling of Energy

HS-LS1-5
Students who demonstrate understanding can:
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

HS-LS1-7
Students who demonstrate understanding can:
Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

HS-LS2-3
Students who demonstrate understanding can:
Construct and revise an explanation based on evidence for the cycling of matter and the flow of energy in aerobic and anaerobic conditions.

In Lay Terms

The processes of photosynthesis (making oxygen and sugar, done in plants) and cellular respiration (making energy from sugar, done in plants and animals) provide most of the energy for life on earth.

Three Dimensional Storyline

Most energy for life processes is provided for organisms through the processes of photosynthesis and cellular respiration. These processes involve the transfer of energy from sunlight to chemical energy through photosynthesis and that chemical energy is used through the process of cellular respiration.

To assist students in their understanding of these concepts and ideas, they should be able to develop and use models based on evidence to illustrate the relationships between photosynthesis and cellular respiration. Students can also develop and using models to investigate how the energy and molecules produced through these processes are transferred in a system. The students should be able to construct and revise an explanation, based on evidence from a variety of sources, for how these processes influence our present world, influenced our past world, and how they will influence our future.

Energy is driven through these systems through the process of photosynthesis whereby light energy transforms into chemical energy that is then stored as sugars. Students can investigate how the inputs and outputs of photosynthesis relate to models of cellular respiration (e.g. diagrams,

chemical equations, or laboratory investigations). The use of sugar, an output of photosynthesis, in cellular respiration allows for the movement of energy through an ecosystem. Investigating this relationship allows students to construct and revise an explanation for how chemical elements are combined and recombined to form different products. Organisms can carry out cellular respiration, through both aerobic and anaerobic conditions, which allows for the cycling of matter and energy within ecosystems.

Lesson Level Performance Expectations

- Students can construct drawings or representations of chemical elements recombining to form different products as matter and energy flow through a system.
- Students can discuss the limitations and precision of a model as it accounts for, or does not account for the quantity of energy transfer in a living system.
- Students can represent and explain, with multiple models, the process of photosynthesis.
- Students can represent and explain, with multiple models, the process of cellular respiration.
- Students can use a variety of models to explain how cellular respiration releases energy needed to maintain body temperature despite surrounding environment.
- Students can engage in an argument from evidence how and why photosynthesis and cellular respiration provide most of the energy for life processes.
- Students can engage in an argument from evidence how the processes of photosynthesis and cellular respiration are dependent upon one another.

Misconceptions	Accurate Concept
1. Carbon dioxide is an energy source for plants. 2. Source of biomass in plants comes from the soil.	1. Carbon dioxide is used during photosynthesis to make sugar used a food/energy source for plants. 2. The biomass in plants comes from carbon from carbon dioxide taken in from the air.

References

- http://umaine.edu/center/files/2009/11/Clegg_Thesis_FINAL.pdf
- http://www.ped.muni.cz/z21/knihy/2010/26/26/texty/eng/bajd_praprotnik_matyasek_e.pdf

Bundle: Cycling of Matter

HS-LS1-6

Students who demonstrate understanding can:

Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules

HS-LS2-4

Students who demonstrate understanding can:

Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS2-5

Students who demonstrate understanding can:

Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

In Lay Terms

Molecules combine and break apart and recombine to form necessary compounds for life. These include: sugars, amino acids, proteins, and carbohydrates. The process of creating these compounds is done by plants and animals at a cellular level. It also occurs in systems in our atmosphere. In all cases, recycling of matter to make these compounds is essential and conserved as it moves through an ecosystem.

Three Dimensional Storyline

All life is dependent on energy and matter. Due to this, organisms must obtain energy and matter from other organisms or from the environment around them. By better understanding the flow of energy and cycling of matter in an ecosystem, students can see how organisms make, or obtain biological molecules like sugars, amino acids, proteins, and carbohydrates. Through this bundle of performance expectations, students can see how matter and energy are not created or destroyed but recycled within organisms, between organisms, or within ecosystems. By examining the inputs and outputs within systems like cells, organisms, or ecosystems students can construct explanations for how energy and matter flow in that system. Students can use a variety of models to explore the flow of energy and matter in such systems (physical, mathematical or computer models).

All life requires the input of energy and matter. All organisms have the complex structural organization needed to capture, transform, transport, and eliminate the matter and energy used to sustain life. Matter and energy flow through all the different levels of life, including the cellular level, tissues, organ systems, whole organisms, populations of organisms, communities of a variety of organisms, all the way to the ecosystem level. As

energy and matter cycle through these levels, chemical reactions utilize and release energy while rearranging chemical elements and molecules to create the compounds necessary for life functions. Carbon is an essential element cycled through these various levels and utilized in the survival of all living organisms as it serves as a backbone for sugars, fats, proteins and DNA. For example, through the process of photosynthesis a plant gains inputs of energy (sunlight) and matter (carbon dioxide and water) to produce a hydrocarbon backbone of sugar. Through the process of cellular respiration, sugar molecules can be broken down and their components rearranged to "make other large molecules that can be assembled into larger molecules, such as proteins or DNA. As these molecules cycle through the ecosystem level they are passed from organism to organisms. When an organism obtains these molecules, the molecules can combine with other chemical elements to continually make different products essential for life functions. Through combinations of their own investigations, simulations and/or models students can construct explanations for how these processes work and how energy is transferred while matter is cycled.

The matter is never destroyed but simply transferred between organisms, reacted with to release energy for life functions, stored in newly made structures, and/or discarded. The inefficiency of the transferring of this matter influences the populations at each level in an ecosystem. Students can examine this inefficiency through mathematical representations of stored energy in biomass a different trophic levels.

To assist students in their understanding of these ideas they can develop and use models to show relationships between organisms and their environment as they cycle the biological molecules of life, and use those models to predict how matter will continue to cycle in a specific system. These models could include, but are not limited to, food webs, food chains, and ecological pyramids. Their analysis of these models (especially ecological pyramids) should use mathematical or computational thinking to support explanations for the relationship between the amounts of matter that being transferred in a system and the population of organisms in the system.

Lesson Level Performance Expectations

- Students can represent and explain, through multiple models, the breaking down and forming of carbon and hydrogen bonds to form the biological molecules of life.
- Students can construct drawings or diagrams as representations of how chemical elements are recombined in different ways to form different products as they flow through levels of living systems.
- Students can construct an explanation for why plants and algae form the lowest level of the food web and why there are fewer apex predators at the highest levels of a food web.
- Students can express relationships and quantities in appropriate mathematical forms to describe the small quantity of energy that is transferred at each link upward in a food web to produce growth and release energy in cellular respiration.
- Students can use mathematical representations to support the claim that energy loss at each trophic level influences populations of organisms at higher levels of a food web.
- Students can construct an explanation for why some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded.

- Students can use drawings or diagrams to explain how chemical elements pass through food webs, into and out of the atmosphere and soil, and are combined in different ways.
- Students can explain the phenomena, through different types of models, that matter and energy are conserved in an ecosystem.
- Students can develop a model to explain the relationship between the processes of photosynthesis and cellular respiration and the carbon cycle.
- Students can develop a model to show how the process of photosynthesis captures solar energy and stores it in plants.

Misconceptions	Accurate Concept
1. Plants take in food from the outside environment, and/or plants get their food from the soil via roots.	1. Plants create their own food using sunlight and carbon dioxide through photosynthesis.
2. Energy can be created or destroyed.	2. Energy cannot be created or destroyed, but is transformed or transferred within a system.
3. Organisms higher in a food web eat everything that is lower in the food web.	3. Organisms higher in a food chain eat some, but not necessarily all, of the organisms below them in the food web.
4. Food webs are interpreted as simple food chains.	4. Food webs most accurately depict the flow of energy within an ecosystem. They depict a complex set of relationships that is not easily simplified to a food chain.
5. The top of the food chain has the most energy because it accumulates up the chain.	5. Energy is transferred among all components of a food web.
6. Populations higher on a food web increase in number because they deplete those lower in the web.	6. Organisms at the top of a food web typically require more energy than those lower in the food web. While some carnivores may be larger and require more food than some herbivores, they do not have more energy or power.
7. There are more herbivores because people keep and breed them.	7. There are more herbivores than carnivores because of the decreasing amount of energy available at each level of the food web.
8. Decomposers release some energy that is cycled back to plants.	8. Decomposers break down dead organisms, returning nutrients to the soil so they can be used by plants. Some decomposers are eaten by carnivores.
9. Plants are dependent on humans, not vice versa.	9. Humans (and all other animals) are dependent on plants.
10. Carbon dioxide is a source of energy for plants.	10. Carbon dioxide is used during photosynthesis to make sugars used for food.

References

- http://www.haspi.org/curriculum-library/Med-Bio-Core-Labs/00%20NEW%20NGSS%20Med%20Bio%20Labs%20COMPLETE/12%20Teacher%20-%20Cycling%20of%20Matter.pdf
- http://energyeducation.eku.edu/sites/energyeducation.eku.edu/files/energyFlowinEcologicalSystems.pdf

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