Life Science EALR 4 – The Three Big Ideas

1) **Structures and Functions of Living Organisms**
   Living organisms are complex systems that gather energy and material from the environment to carry on life processes. In the earliest grades students learn that plants and animals have body parts with different functions to meet their needs. In grades 2 and 3 students compare the life cycles of various plants and animals, and in grades 4 and 5 they learn about the various structures and behaviors that enable plants and animals to respond to their needs. Focus in middle school is on cells—the fundamental unit of life. Cells combine to make tissues, which make up organs that function together in organ systems that cumulatively form the whole organism. At each level of organization, structures enable functions required by the organism. The complex internal structure and functions of cells are the focus in high school. Information for producing proteins and reproduction is coded in DNA molecules, which are organized into genes and chromosomes. This elegant yet complex set of processes answers fundamental questions about how life functions and how life forms are able to replicate themselves with slight changes that make it possible for species to adapt to changing conditions.

2) **Ecosystems**
   An ecosystem includes all of the plant and animal populations and nonliving resources in a given area. In grades 2 and 3, students learn that every organism obtains materials and energy from the environment to meet its needs. In grades 4 and 5, students learn that each organism has a different relationship to every other organism in its ecosystem. Plants have a special role as producers that make their own food and provide food for all other organisms. A food web shows how energy makes its way from organism to organism through the ecosystem. Middle school students learn that different ecosystems have similar patterns in the ways that matter and energy flow through them. High school students focus on the flow of energy through ecosystems and the factors that maintain an ecosystem’s long-term stability, as well as factors that can destabilize an ecosystem, such as the introduction of new species. Students consider the effects of harvesting resources in ecosystems and the concept of sustainable development.

3) **Biological Evolution**
   Evolution is the essential framework for understanding change in organisms over time. In the earliest grades children learn about the amazing diversity of Earth’s organisms and their relatedness to one another. In grades 2 and 3 students observe that offspring of plants and animals closely resemble their parents, but offspring are never exactly the same as their parents. In grades 4 and 5 students learn that some characteristics are acquired and others are inherited. In middle school they learn that the processes of inheritance, mutation, and natural selection account for the diversity of species that exist today. High school students learn about the major factors that drive evolution and the molecular basis for inheritance and mutation. Students learn more about the processes of evolution by the classification of organisms and by tracing the evolution of a single species.

1) **Big Idea: Structures and Functions of Living Organisms (LS1)**

Core Content: **Processes Within Cells** In prior grades students learned that all living systems are composed of cells which make up tissues, organs, and organ systems. In grades 9-11 students learn that cells have complex molecules and structures that enable them to carry out life functions such as photosynthesis and respiration and pass on their characteristics to future generations. Information for producing proteins and reproduction is coded in DNA and organized into genes in chromosomes. This elegant yet complex set of processes explains how life forms replicate themselves with slight changes that make adaptations to changing conditions possible over long periods of time. These processes that occur within living cells help students understand the commonalities among the diverse living forms that populate Earth today.

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| 9-11 LS1A | Carbon-containing *compounds* are the building blocks of life. *Photosynthesis* is the process that plant cells use to combine the energy of sunlight with *molecules* of carbon dioxide and water to produce energy-rich *compounds* that contain carbon (*food*) and release oxygen. | *Explain how plant cells use *photosynthesis* to produce their own food. Use the following equation to illustrate how plants rearrange *atoms* during *photosynthesis*:  
6CO2+6H2O+light energy → C6H12O6+6O2  
*a*  
*Explain the importance of *photosynthesis* for both plants and animals, including humans.* |
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<td>9-11 LS1B</td>
<td>The gradual combustion of carbon-containing <em>compounds</em> within cells, called <em>cellular respiration</em>, provides the primary energy source of living <em>organisms</em>; the combustion of carbon by burning of <em>fossil fuels</em> provides the primary energy source for most of modern society.</td>
<td><em>Explain how the process of <em>cellular respiration</em> is similar to the burning of <em>fossil fuels</em> (e.g., both processes involve combustion of carbon-containing <em>compounds</em> to transform chemical energy to a different <em>form</em> of energy).</em> <em>a</em></td>
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<td>9-11 LS1C</td>
<td>Cells contain specialized parts for determining essential <em>functions</em> such as regulation of cellular activities, energy capture and release, formation of proteins, waste disposal, the <em>transfer</em> of information, and movement.</td>
<td>Draw, label, and <em>describe</em> the <em>functions</em> of components of essential structures within cells (e.g., <em>cellular membrane</em>, <em>nucleus</em>, <em>chromosome</em>, <em>chloroplast</em>, <em>mitochondrion</em>, <em>ribosome</em>)</td>
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<td>9-11 LS1D</td>
<td>The cell is surrounded by a membrane that separates the interior of the cell from the outside world and determines which substances may enter and which may leave the cell.</td>
<td><em>Describe</em> the structure of the `` and how the membrane regulates the flow of materials into and out of the cell.</td>
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| 9-11 LS1E | The *genetic information* responsible for inherited *characteristics* is encoded in the *DNA molecules* in *chromosomes*. DNA is composed of four subunits (A,T,C,G). The sequence of subunits in a *gene* specifies the amino acids needed to make a protein. *Proteins* express inherited traits (e.g., eye color, hair texture) and carry out most cell *function*. | *Describe* how DNA *molecules* are long chains linking four subunits (smaller *molecules*) whose sequence encodes *genetic information*.  
Illustrate the process by which *gene* sequences are copied to produce proteins. |
| 9-11 LS1F | All of the functions of the cell are based on chemical reactions. Food molecules are broken down to provide the energy and the chemical constituents needed to synthesize other molecules. Breakdown and synthesis are made possible by proteins called | *Explain how cells break down food molecules and use the constituents to synthesize proteins, sugars, fats, DNA and many other molecules that cells require.*  
Describe the role that enzymes play in the breakdown of food molecules and synthesis of the many different molecules needed for |
enzymes. Some of these enzymes enable the cell to store energy in special chemicals, such as ATP, that are needed to drive the many other chemical reactions in a cell.

| 9-11 LS1G | Cells use the DNA that forms their genes to encode enzymes and other proteins that allow a cell to grow and divide to produce more cells, and to respond to the environment. | Explain how cells extract and store energy from food molecules. |

| 9-11 LS1H | Genes are carried on chromosomes. Animal cells contain two copies of each chromosome with genetic information that regulate body structure and functions. Cells divide by a process called mitosis, in which the genetic information is copied so that each new cell contains exact copies of the original chromosomes. | Describe and model the process of mitosis, in which one cell divides, producing two cells, each with copies of both chromosomes from each pair in the original cell. |

| 9-11 LS1I | Egg and sperm cells are formed by a process called meiosis in which each resulting cell contains only one representative chromosome from each pair found in the original cell. Recombination of genetic information during meiosis scrambles the genetic information, allowing for new genetic combinations and characteristics in the offspring. Fertilization restores the original number of chromosome pairs and reshuffles the genetic information, allowing for variation among offspring. | Describe and model the process of meiosis in which egg and sperm cells are formed with only one set of chromosomes from each parent. Model and explain the process of genetic recombination that may occur during meiosis and how this then results in differing characteristics in offspring. Describe the process of fertilization that restores the original chromosome number while reshuffling the genetic information, allowing for variation among offspring. Predict the outcome of specific genetic crosses involving two characteristics *a, *b |

**Mathematics Connections**
* a A1.3.B Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
* b A1.6.B Make valid inferences and draw conclusions based on data.
## 2) Big Idea: Ecosystems (LS2)

### Core Content: Maintenance and Stability of Populations
In prior grades students learned to apply key concepts about ecosystems to understand the interactions among organisms and the nonliving environment. In grades 9-11 students learn about the factors that foster or limit growth of populations within ecosystems and that help to maintain the health of the ecosystem overall. Organisms participate in the cycles of matter and flow of energy to survive and reproduce. Given abundant resources, populations can increase at rapid rates. But living and nonliving factors limit growth, resulting in ecosystems that can remain stable for long periods of time. Understanding the factors that affect populations is important for many societal issues, from decisions about protecting endangered species to questions about how to meet the resource needs of civilization while maintaining the health and sustainability of Earth’s ecosystems.

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<td>9-11 LS2A Matter cycles and energy flows through living and nonliving components in ecosystems. The transfer of matter and energy is important for maintaining the health and sustainability of an ecosystem.</td>
<td><em>a</em> Explain how plants and animals cycle carbon and nitrogen within an ecosystem. Explain how matter cycles and energy flows in ecosystems, resulting in the formation of differing chemical compounds and heat.</td>
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<td>9-11 LS2B Living organisms have the capacity to produce very large populations. Population density is the number of individuals of a particular population living in a given amount of space.</td>
<td><em>a</em> Evaluate the conditions necessary for rapid population growth (e.g., given adequate living and nonliving resources and no disease or predators, populations of an organism increase at rapid rates). Given ecosystem data, calculate the population density of an organism.</td>
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<td>9-11 LS2C Population growth is limited by the availability of matter and energy found in resources, the size of the environment, and the presence of competing and/or predatory organisms.</td>
<td><em>a</em> Explain factors, including matter and energy, in the environment that limit the growth of plant and animal populations in natural ecosystems.</td>
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<td>9-11 LS2D Scientists represent ecosystems in the natural world using mathematical models.</td>
<td><em>a, b</em> Draw a systems diagram to illustrate and explain why introduced (nonnative) species often do poorly and have a tendency to die out, as well as why they sometimes do very well and force out native species.</td>
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<td>9-11 LS2E Interrelationships of organisms may generate ecosystems that are stable for hundreds or thousands of years. Biodiversity refers to the different kinds of organisms in specific ecosystems or on the planet as a whole.</td>
<td><em>a</em> Compare the biodiversity of organisms in different types of ecosystems (e.g., rain forest, grassland, desert) noting the interdependencies and interrelationships among the organisms in these different ecosystems.</td>
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The concept of sustainable development supports adoption of policies that enable people to obtain the resources they need today without limiting the ability of future generations to meet their own needs. Sustainable processes include substituting renewable for nonrenewable resources, recycling, and using fewer resources.

Explain how scientific concepts and findings relate to a resource issue currently under discussion in the state of Washington (e.g., removal of dams to facilitate salmon spawning in rivers; construction of wind farms).* a,*b,*c.

Explain how the concept of sustainable development may be applied to a current resource issue in the state of Washington.*a,*b,*c.

### Mathematics Connections
*a A1.8.A Analyze a problem situation and represent it mathematically.
7.2.E Represent proportional relationships using graphs, tables, and equations, and make connections among the representations.
A1.3.B Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
A1.2.B Recognize the multiple uses of variables, determine all possible values of variables that satisfy prescribed conditions, and evaluate algebraic expressions that involve variables.
*b A1.6.B Make valid inferences and draw conclusions based on data.
A1.7.D Solve an equation involving several variables by expressing one variable in terms of the others.
*c A1.3.B Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
A1.6.B Make valid inferences and draw conclusions based on data.

### 3) Big Idea: Biological Evolution (LS3)

**Core Content: Mechanisms of Evolution** In prior grades students learned how the traits of organisms are passed on through the transfer of genetic information during reproduction. In grades 9-11 students learn about the factors that underlie biological evolution: variability of offspring, population growth, a finite supply of resources, and natural selection. Both the fossil record and analyses of DNA have made it possible to better understand the causes of variability and to determine how the many species alive today are related. Evolution is the major framework that explains the amazing diversity of life on our planet and guides the work of the life sciences.

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<td><strong>9-11 LS3A</strong></td>
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<td>Biological evolution is due to: (1) genetic variability of offspring due to mutations and genetic recombination, (2) the potential for a species to increase its numbers, (3) a finite supply of resources, and (4) natural selection by the environment for those offspring better able to survive and reproduce.</td>
<td>Explain biological evolution as the consequence of the interactions of four factors: population growth, inherited variability of offspring, a finite supply of resources, and natural selection by the environment of offspring better able to survive and reproduce. Predict the effect on a species if one of these factors should change.*a</td>
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### 9-11 LS3B
**Random changes in the genetic makeup of cells and organisms (mutations) can cause changes in their physical characteristics or behaviors. If the genetic mutations occur in eggs or sperm cells, the changes will be inherited by offspring. While many of these changes will be harmful, a small minority may allow the offspring to better survive and reproduce.**

**Describe the molecular process by which organisms pass on physical and behavioral traits to offspring, as well as the environmental and genetic factors that cause minor differences (variations) in offspring or occasional ―mistakes‖ in the copying of genetic material that can be inherited by future generations (mutations).**

**Explain how a genetic mutation may or may not allow a species to survive and reproduce in a given environment.**

### 9-11 LS3C
**The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled available ecosystem niches on Earth with life forms.**

**Explain how the millions of different species alive today are related by descent from a common ancestor.**

**Explain that genes in organisms that are very different (e.g., yeast, flies, and mammals) can be very similar because these organisms all share a common ancestor.**

### 9-11 LS3D
**The fossil record and anatomical and molecular similarities observed among diverse species of living organisms provide evidence of biological evolution.**

**Using the fossil record and anatomical and/or molecular (DNA) similarities as evidence, formulate a logical argument for biological evolution as an explanation for the development of a representative species (e.g., birds, horses, elephants, whales).**

### 9-11 LS3E
**Biological classifications are based on how organisms are related, reflecting their evolutionary history. Scientists infer relationships from physiological traits, genetic information, and the ability of two organisms to produce fertile offspring.**

**Classify organisms, using similarities and differences in physical and functional characteristics.**

**Explain similarities and differences among closely related organisms in terms of biological evolution (e.g., —Darwin’s finches had different beaks due to food sources on the islands where they evolved).**

### Mathematics Connections

*a 8.3.F Determine probabilities for mutually exclusive, dependent, and independent events for small sample sizes.*