EALR 1: **Systems**

Big Idea: **Systems (SYS)**

Core Content: ***Predictability and Feedback***

In prior grades students learned how to simplify and analyze complex situations by thinking about them as systems. In grades 9-12 students learn to construct more sophisticated system models, including the concept of feedback. Students are expected to determine whether or not systems analysis will be helpful in a given situation and if so, to describe the system, including subsystems, boundaries, flows, and feedbacks. The next step is to use the system as a dynamic model to predict changes. Students are also expected to recognize that even the most sophisticated models may not accurately predict how the real world functions. This deep understanding of systems and ability to use systems analysis is an essential tool both for scientific inquiry and for technological design.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
9-12 SYSA	*Feedback* is a process in which the *output* of a *system* provides information used to regulate the operation of the *system*. Positive *feedback* increases the disturbance to a *system*. Negative *feedback* reduces the disturbance to a *system*.	• Give examples of a positive *feedback system* and *explain* its regulatory mechanism (e.g., global warming causes Earth's ice caps to melt, reflecting less *energy* to space, increasing *temperatures*).*a • Give examples of a negative *feedback system* and *explain* its regulatory mechanism (e.g., when a human body overheats, it produces sweat that cools the body by *evaporation*).*a
9-12 SYSB	*Systems* thinking can be especially useful in *analyzing* complex situations. To be useful, a *system* needs to be specified as clearly as possible.	• Determine if a *systems* approach will be helpful in answering a *question* or solving a problem.*b • Represent the *system* with a diagram specifying components, boundaries, flows, and *feedbacks*.*a • *Describe* relevant *subsystems* and the larger *system* that contains the *system* being analyzed.*a • Determine how the *system functions* with respect to other *systems*.
9-12 SYSC	In complex *systems*, entirely new and unpredictable *properties* may emerge. Consequently, modeling a complex *system* in sufficient detail to make *reliable predictions* may not be possible.	• Create a simplified *model* of a complex *system*. Trace the possible consequences of a change in one part of the *system* and *explain how* the simplified *model* may not be adequate to reliably *predict* consequences.
9-12 SYSD	*Systems* can be changing or in *equilibrium*.	• *Analyze* whether or not a *system* (e.g., population) is changing or in *equilibrium*. *c • Determine whether a *state of equilibrium* is static or dynamic (e.g., inflows equal outflows). *c

Mathematics Connections

*a	A1.8.A	Analyze a problem situation and represent it mathematically.
	A1.1.A	Select and justify functions and equations to model and solve problems.
*b	A1.8.B	Select and apply strategies to solve problems.
	A1.8.D	Generalize a solution strategy for a single problem to a class of related problems, and apply a strategy for a class of related problems to solve a specific problem.
*c	A1.8.H	Use inductive reasoning about algebra and the properties of numbers to make conjectures, and use deductive reasoning to prove or disprove conjectures.
	A1.7.C	Express arithmetic and geometric sequences in explicit and recursive forms, translate between the two forms, explain how rate of change is represented in each form, and use the forms to find specific terms in the sequence.

EALR 2: **Inquiry**

Big Idea: **Inquiry (INQ)**

Core Content: ***Conducting Analyses and Thinking Logically***

In prior grades students learned to revise questions so they can be answered scientifically. In grades 9-12 students extend and refine their understanding of the nature of inquiry and their ability to formulate questions, propose hypotheses, and design, conduct, and report on investigations. Refinement includes an increased understanding of the kinds of questions that scientists ask and how the results reflect the research methods and the criteria that scientific arguments are judged by. Increased abilities include competence in using mathematics, a closer connection between student-planned investigations and existing knowledge, improvements in communication and collaboration, and participation in a community of learners.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
9-12 INQA Question	Scientists *generate* and *evaluate questions* to *investigate* the *natural world.*	• *Generate* and *evaluate* a *question* that can be answered through a scientific *investigation.* Critique *questions generated* by others and *explain* whether or not the *questions* are scientific.*a
9-12 INQB Investigate	Scientific progress requires the use of various methods appropriate for answering different kinds of research *questions*, a thoughtful plan for gathering data needed to answer the *question*, and care in collecting, *analyzing*, and displaying the data.	• Plan and conduct a scientific *investigation*, choosing a method appropriate to the *question* being asked. • Collect, *analyze*, and display data using calculators, computers, or other technical devices when available.*b
9-12 INQC Explain	*Conclusions* must be logical, based on *evidence*, and consistent with prior *established* knowledge.	• Draw *conclusions* supported by *evidence* from the *investigation* and consistent with *established* scientific knowledge.*c • Analyze alternative explanations and decide which best fits the data and *evidence.**d
9-12 INQD Communicate Clearly	The methods and procedures that scientists use to obtain *evidence* must be clearly reported to enhance opportunities for further *investigation.*	• Write a detailed laboratory report that includes: the *question* that motivated the study, a justification for the kind of *investigation* chosen, *hypotheses* (if any), a description of what was done, a summary of data in tables and graphs, and a *conclusion*, based on the *evidence*, that responds to the *question.*
9-12 INQE Model	The essence of scientific *investigation* involves the development of a *theory* or conceptual *model* that can *generate* testable predictions.	• Formulate one or more *hypotheses* based on a *model* or *theory* of a causal *relationship.* Demonstrate creativity and critical thinking to formulate and *evaluate* the *hypotheses.*
9-12 INQF Communicate	*Science* is a human endeavor that involves logical reasoning and creativity and entails the testing, revision, and occasional discarding of theories as new *evidence* comes to light.	• *Evaluate* an *investigation* to determine if it was a *valid* means of answering the *question*, and whether or not the results were *reliable.* *e • *Describe* the development of a scientific *theory* that illustrates logical reasoning, creativity, testing, revision, and replacement of prior *ideas* in light of new *evidence.*

	Content Standards	Performance Expectations
9-12 INQG Intellectual Honesty	Public *communication* among scientists is an essential aspect of research. Scientists *evaluate* the *validity* of one another's *investigations*, check the *reliability* of results, and *explain* inconsistencies in findings.	• Participate in a scientific discussion about one's own *investigations* and those performed by others. • Respond to *questions* and criticisms, and if appropriate, revise explanations based on these discussions.
9-12 INQH Intellectual Honesty	Scientists carefully *evaluate* sources of information for *reliability* before using that information. When referring to the *ideas* or findings of others, they cite their sources of information.	• Provide appropriate citations for all *ideas*, findings, and information used in any and all written reports. • *Explain* the consequences for failure to provide appropriate citations.

Mathematics Connections

*a	8.5.H	Make and test conjectures based on data or information collected from explorations and experiments.
*b	8.5.D	Represent a problem situation, describe the process used to solve the problem, and verify the reasonableness of the solution.
	A1.8.A	Analyze a problem situation and represent it mathematically.
	A2.1.A	Select and justify functions and equations to model and solve problems.
	A2.6.F	Calculate and interpret measures of variability and standard deviation, and use these measures to describe and *compare* data sets.
	A1.8.F	Summarize mathematical ideas with precision and efficiency for a given audience and purpose.
	A1.6.E	Describe the correlation of data in scatter plots in terms of strong or weak and positive or negative.
*c	A1.6.B	Make valid inferences and draw conclusions based on data.
	A1.8.G	Synthesize information to draw conclusions and evaluate the arguments and conclusions of others.
*d	A1.6.D	Find the equation of a linear function that best fits bivariate data that are linearly related, interpret the slope and the y-intercept of the line, and use the equation to make predictions.
	A1.8.H	Use inductive reasoning about algebra and the properties of numbers to make conjectures, and use deductive reasoning to prove or disprove conjectures.
*e	G.7.C	Evaluate a solution for reasonableness, verify its accuracy, and interpret it in the context of the original problem.
	A1.8.C	Evaluate a solution for reasonableness, verify its accuracy, and interpret the solution in the context of the original problem.

Note: This standard is closely aligned to Mathematics Core Processes A1.8 and G.7.

EALR 3: **Application**

Big Idea: **Application (APP)**

Core Content: ***Science, Technology, and Society***

In prior grades students learn to work with other members of a team to apply the full process of technological design and relevant science concepts to solve problems. In grades 9-12 students apply what they have learned to address societal issues and cultural differences. Students learn that science and technology are interdependent, that science and technology influence society, and that society influences science and technology. Students continue to increase their abilities to work with other students and to use mathematics and information technologies (when available) to solve problems. They transfer insights from those increased abilities when considering local, regional, and global issues. These insights and capabilities will help prepare students to solve societal and personal problems in future years.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
9-12 APPA	*Science* affects society and *cultures* by influencing the way many people think about themselves, others, and the *environment*. Society also affects *science* by its prevailing views about what is important to study and by deciding what research will be funded.	• *Describe* ways that scientific *ideas* have influenced society or the development of differing *cultures*. • List *questions* that scientists *investigate* that are stimulated by the needs of society (e.g., medical research, *global climate* change).
9-12 APPB	The *technological design process* begins by defining a problem in terms of *criteria* and *constraints*, conducting research, and generating several different *solutions*.	• Work collaboratively with other students to *generate ideas* for solving a problem. Identify *criteria* and *constraints*, research the problem, and *generate* several possible *solutions*.
9-12 APPC	Choosing the best *solution* involves comparing alternatives with respect to *criteria* and *constraints*, then building and testing a *model* or other representation of the final design.	• Choose the best *solution* for a problem, create a *model* or drawing of the final design, and devise a way to test it. Redesign the *solution*, if necessary, then present it to peers.*b
9-12 APPD	The ability to solve problems is greatly enhanced by use of mathematics and information technologies.	• Use proportional reasoning, functions, graphing, and estimation to solve problems.*a*b*c • Use computers, probes, and software when available to collect, display, and analyze data.
9-12 APPE	Perfect *solutions* do not exist. All technological *solutions* involve trade-offs in which decisions to include more of one quality means less of another. All *solutions* involve consequences, some intended, others not.	• *Analyze* a societal issue that may be addressed through *science* and/or *technology*. *Compare* alternative *solutions* by *considering trade-offs* and unintended consequences (e.g., removing dams to increase salmon spawning).
9-12 APPF	It is important for all citizens to *apply science* and *technology* to critical issues that influence society.	• Critically *analyze* scientific information in current events to make personal choices or to understand public-policy decisions.*d

Mathematics Connections

*a	A1.8.A	Analyze a problem situation and represent it mathematically.
*b	A1.8.C	Evaluate a solution for reasonableness, verify its accuracy, and interpret it in the context of the original problem.
*c	A1.3B.	Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
*d	A1.8.G	Synthesize information to draw conclusions and evaluate the arguments and conclusions of others.

EALR 4: **Life Science**

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.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
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*: $6CO_2+6H_2O$+light *energy* —> $C_6H_{12}O_6+6O_2$ *a • *Explain* the importance of *photosynthesis* for both plants and animals, including humans.
9-11 LS1B	The gradual combustion of carbon-containing *compounds* within cells, called *cellular respiration*, provides the primary *energy* source of living *organisms*; the combustion of carbon by burning of *fossil fuels* provides the primary *energy* source for most of modern society.	• *Explain how* the process of *cellular respiration* is similar to the burning of *fossil fuels* (e.g., both processes involve combustion of carbon-containing *compounds* to *transform* chemical *energy* to a different *form* of *energy*). *a
9-11 LS1C	Cells contain specialized parts for determining essential *functions* such as regulation of cellular activities, *energy* capture and release, formation of proteins, waste disposal, the *transfer* of information, and movement.	• Draw, label, and *describe* the *functions* of components of essential structures within cells (e.g., *cellular membrane, nucleus, chromosome, chloroplast, mitochondrion, ribosome*)
9-11 LS1D	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.	• *Describe* the structure of the *cell membrane* and how the membrane regulates the flow of materials into and out of the cell.
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.

	Content Standards	Performance Expectations
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 *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.	• *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 cell structure and *function*. • *Explain how* cells extract and store *energy* from food *molecules*.
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 that* regulation of cell *functions* can occur by changing the activity of proteins within cells and/or by changing whether and how often particular *genes* are expressed.
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*. Most 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.

EALR 4: **Life Science**

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.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
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.*	• *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.*
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.	• *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.**a
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*.	• *Explain factors,* including matter and *energy*, in the *environment* that limit the growth of plant and animal *populations* in natural *ecosystems.**a
9-11 LS2D	Scientists represent *ecosystems* in the *natural world* using mathematical *models.*	• 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*. *a, *b
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.	• *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.*

	Content Standards	Performance Expectations
9-11 LS2F	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.

EALR 4: **Life Science**

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.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
9-11 LS3A	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 produce offspring.	• *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
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).

	Content Standards	Performance Expectations
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.