Biology Syllabus
Ann Arbor Public Schools

Students must score a minimum of 77% on the exam in order to earn credit by testing out. In addition to assessing basic understanding of core ideas for the discipline of Biology, the questions will assess science practices and reasoning. In order to assess the nature of the Michigan Science Standards, there is a greater emphasis on constructed response items than you might anticipate.

Note that the science standards are listed in the lower part of this document in full. You should make a careful review of all the statements of performance, practice and core ideas.

Please anticipate that a significant portion of the test-out exam will assess science reasoning skills and science practices consistent with what we expect of students at the end of 9^{th} grade Biology. Students will need to demonstrate that they can apply their conceptual understanding to explaining phenomena in the world. This includes demonstrating their ability to:

- **Interpret graphs and analyze data-** practice with these skills is interwoven throughout the textbook and includes tabular data, line graphs, histograms, pie graphs and scatter plots. Basic statistical analysis is also expected.
    - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
    - Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
    - Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
    - Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
    - Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
    - Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
- **Use apparatus and technology important for investigations** in Biology (microscopes, petri dishes, CO_2 & pH sensors, for example)
- **Develop appropriate investigation procedures** for a given testable question & make valid conclusions for given results. Topics for investigation will be consistent with those addressed in the course.
- **Create written arguments** by making an appropriate claim supported by evidence and reasoning- rubric here.
- **Develop and Use Models** to include:
    - Developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence .
- Design a test of a model to ascertain its reliability.
- Develop, **revise,** and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
- Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
- Resources to understand more about developing and using models and some tools for creating models. Keep in mind that a model can be a simple diagram or a digital representation that shows the relationships between elements of a system, provides an explanation (shows how/why) for what happens in the system and can be used to predict future events or data for the system.

Textbook: *Biology* (Holt McDougal, 2012), Author: Stephen Nowicki is a resource available in the book depository at the AAPS comprehensive high schools. Students will need to provide verification of test out registration to obtain/check out a copy. Just print your registration confirmation email/pdf and take this to the book depository at the comprehensive high school a student does or will attend. Links to relevant digital content provided below are an alternative reference for those who would prefer a digital resource.

Semester 1	**Textbook**
How Science Works	Ch. 1 Video Resource How Science Works - explore this resource thoroughly! Digital Resources: 1.1 Scientific Method 1.2 Experiment 1.3 Scientific Theories 1.4 Characteristics of Life 1.5 Principles of Biology 1.6 Interdependence of Living Things 1.7 Organization of Living Things 1.8 Evolution of Life
1.1 Cells and DNA	Ch. 2/3/18 Digital Resources: 1.9 Significance of Carbon 1.10 Carbohydrates 1.11 Proteins 1.12 Lipids 1.13 Nucleic Acids 1.14 Biochemical Reactions 1.15 Energy and Biochemical Reactions 1.16 Types of Biochemical Reactions 1.17 Enzymes 1.18 Enzyme Function 1.19 Water and Life 1.20 Acids and Bases 2.1 Parts of the Cell 2.2 Prokaryotic and Eukaryotic Cells 2.3 Phospholipid Bilayer 2.4 Membrane Proteins 2.5 Cytoplasm and Cytoskeleton

2.6 Nucleus
2.7 Ribosomes and Mitochondria
2.8 Cell Structure
2.9 Plant Cell Structure
2.10 Cell Organization
2.11 Diffusion
2.12 Osmosis
2.13 Passive Transport
2.14 Active Transport
7.1 Prokaryotes
7.2 Bacteria Classification
7.3 Bacteria Structure
7.4 Bacteria Nutrition
7.5 Bacteria Habitat
7.6 Bacteria Reproduction
7.7 Bacteria and Humans
7.8 Viruses
7.9 Virus Characteristics
7.10 Virus Structure
7.11 Virus Classification
7.12 Virus Origin
7.13 Virus Replication
7.14 Viral Disease
7.15 HIV
7.16 Virus Control
7.17 Viruses in Research

1.2 Specialized Cells **Ch. 5/ Ch. 28-34**

(Structure, Function & Homeostasis, including bacteria & virus, in ch. 28-34 emphasis on understanding basic functions of systems and how systems interact to maintain homeostasis)

Comparative Structure and Function as examples of specialization Ch. 21, 23-25

Digital Resources:
2.32 Cell Division
2.33 Cell Cycle
2.34 Chromosomes
2.35 Mitosis
2.36 Reproduction

Organization of the Human Body

13.1 Human Body
13.2 Homeostasis
13.3 Skeletal System
13.8 Muscles
13.11 Skin
13.12 Nails and Hair
13.13 Neuron
13.20 Endocrine Glands
13.21 Hormone
13.22 Hormone Regulation
13.23 Endocrine System Diseases
13.24 Heart
13.25 Blood Vessels
13.26 Circulatory System
13.27 Cardiovascular Diseases
13.28 Blood
13.29 Respiratory System
13.30 Respiratory System Organs
13.31 Breathing

13.32 Regulation of Breathing
13.33 Respiratory System Disorders
13.34 Digestive System Organs
13.35 Digestive System
13.36 Small Intestine
13.37 Large Intestine
13.38 Digestive System Diseases
13.39 Food and Nutrients
13.40 Balanced Eating
13.41 Excretory System
13.42 Urinary System
13.43 Kidneys
13.44 Excretory System Diseases

2.1 Photosynthesis and Cellular Respiration

Ch. 4
Digitial Resources:

2.18 Glucose and ATP
2.19 Chloroplast
2.20 Leaves and Photosynthesis
2.21 Photosynthesis
2.22 Calvin Cycle
2.23 Photosynthesis Summary
2.24 Chemosynthesis
2.25 Aerobic vs Anaerobic Respiration
2.26 Cellular Respiration
2.27 Glycolysis
2.28 Krebs Cycle
2.29 Electron Transport
2.30 Fermentation
2.31 Anaerobic and Aerobic Respiration

2.2 Cycling and Energy Flow in Ecosystems

Ch. 13
Digitial Resources:

6.1 Ecosystems
6.2 Energy Flow
6.3 Food Chain
6.4 Trophic Level
6.5 Water Cycle
6.6 Carbon Cycle
6.7 Nitrogen Cycle

3.1 Populations and carrying capacity

Ch. 14
Digitial Resources:

6.13 Predation
6.14 Competition
6.15 Symbiosis
6.16 Succession
6.17 Population
6.18 Population Structure
6.19 Population Growth
6.20 Population Growth Patterns
6.24 Biodiversity
6.25 Importance of Biodiversity

Semester 2

4.1 DNA Codes for Proteins

Ch. 8
Digitial Resources:

4.1 Central Dogma
4.2 DNA

4.3 DNA Structure and Replication
4.4 RNA
4.5 Transcription
4.6 Genetic Code
4.7 Translation
4.8 Mutation
4.9 Mutation Causes
4.10 Mutation Effects
4.11 Gene Expression
4.12 Prokaryotic Gene Regulation
4.13 Eukaryotic Gene Regulation

4.2 Inheritance and Variation of Traits

Ch. 6, 7, 9
Digitial Resources:
3.1 Pea Plants
3.2 Mendel's First Experiment
3.3 Mendel's Second Experiment
3.4 Mendel's Laws
3.5 Probability
3.6 Punnett Squares
3.7 Non Mendelian Inheritance
3.8 Human Genome
3.9 Human Chromosomes
3.10 Genetic Linkage
3.11 Mendelian Inheritance
3.12 Genetic Disorders
3.13 Biotechnology
3.14 Biotechnology Applications
3.15 Ethical, Legal, and Social Issues in Biotechnology (ELSI)

5.1 Natural selection

Ch 10, 11, 12.3, 12.4
Digitial Resources:
5.14 Theory of Evolution
5.15 Fossils
5.16 Comparative Anatomy
5.17 Biogeography
5.21 Natural Selection
5.23 Coevolution

5.2 Evolution

5.20 Forces of Evolution

5.3 Speciation

5.22 Origin of Species

Important Case Study for Evolution

Drug-Resistant Bacteria - A Global Health Issue

Sample Task for Evolution

Student Directions
Student Questions
Student Map of the Greater Antilles [pdf]
Map Key [pdf]
Anolis Lizard Icons: color or black & white (for students) [both pdf]
Anolis Lizard Data Table
Anolis Lizard Phylogenetic Tree [pdf]
Anolis Lizard Phylogenetic Tree Key [pdf]
Possible Phylogenetic Tree Hypotheses [pdf]

6. Human Impact

Populations & Human Impact on the Environment

Ch. 14, 16

Digitial Resources:

- 6.26 Mass Extinction
- 6.27 Resources
- 6.28 Soil and Water
- 6.29 Air Pollution
- 6.30 Global Warming

Extra resources for consideration:

Sample case-studies around which a performance tasks that check understanding of core ideas and science practices could be developed. Review these case studies to see if you can follow the evidence and the argument in these science stories.

Cells within cells: An extraordinary claim with extraordinary evidence

The structure of DNA: Cooperation and competition

A Lesson to Understand Correlation of Variables by Graphing

Developing and using models

Michigan Science Standards for Biology

This section of the syllabus provides a comprehensive list of the science standards that students that students are expected to master during Biology. They are provided in two formats (and we encourage you to review and consider both):

1) Performance expectations that describe both what students will need to know and do.
2) Separate lists of the core ideas, crosscutting concepts and science practices so that you can consider the knowledge and skills needed more independently of each other. The statements in this format are the same as those embedded in the performance expectations, just broken out and stated independently to provide another way for you to check and consider your knowledge.

Michigan Science Standards - Part 1: Performance Expectations

Structure and Function

HS-LS1-1 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-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Matter and Energy in Organisms and Ecosystems

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

HS-LS1-6 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-LS1-7 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 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. **

HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. **

Interdependent Relationships in Ecosystems
HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-6 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. **

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* **

HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. **

Inheritance and Variation of Traits
HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

HS-LS3-1 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-LS3-2 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 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Michigan Science Standards - Part 2: Embedded in the performance expectations above are the following statements. Here, we have listed them by Core Ideas, Science & Engineering Practices and Crosscutting Concepts broken-down so you can see the specific lists of what you will need to know and do in each of the categories.

Here are the core ideas with which you must be familiar and able to apply:
LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life.(HS-LS1-1)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (HS-LS1-1) *(Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)*
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)

LS1.B: Growth and Development of Organisms

- In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)

LS1.C: Organization for Matter and Energy Flow in Organisms

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5)
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6), (HS-LS1-7)
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6)
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7)

PS3.D: Energy in Chemical Processes and Everyday Life

- The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary to HS-LS2-5)*

LS2.A: Interdependent Relationships in Ecosystems

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1), (HS-LS2-2)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)

- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2), (HS-LS2-6)
- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

LS2.D: Social Interactions and Group Behavior

- Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HS-LS2-8)

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary to HS-LS2-7)*
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary to HS-LS2-7)*

ETS1.B: Developing Possible Solutions

- When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.*(secondary to HS-LS2-7)*

LS1.A: Structure and Function

- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. *(secondary to HS-LS3-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.)*

LS3.A: Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)

LS3.B: Variation of Traits

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2), (HS-LS3-3)

LS4.A: Evidence of Common Ancestry and Diversity

- Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)

LS4.B: Natural Selection

- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2), (HS-LS4-3)
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)

LS4.C: Adaptation

- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)
- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3), (HS-LS4-4)
- Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-5), (HS-LS4-6)
- Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5)

LS4.D: Biodiversity and Humans

- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (HS-LS4-6)

ETS1.B: Developing Possible Solutions

- When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.*(secondary to HS-LS4-6)*
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. *(secondary to HS-LS4-6)*

Cross-cutting concepts that students need to be able to use in making sense of Biological phenomena

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-LS4-1), (HS-LS4-3)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2), (HS-LS4-4), (HS-LS4-5), (HS-LS4-6)

Scale, Proportion, and Quantity

- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-LS3-3)

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)

Energy and Matter

- Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS2-4)
- Energy drives the cycling of matter within and between systems. (HS-LS2-3)

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-LS1-1)

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)

Science & Engineering Practices that will be emphasized

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-2)
- Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-4), (HS-LS1-5), (HS-LS1-7)

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-LS1-3)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-6)
- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-1)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.(HS-LS2-6)
- Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. (HS-LS2-8)
- Identify evidence and match evidence to claims/statements that are consistent with that evidence.

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HS-LS3-3)
- Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships
- Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.
- Distinguish between causal and correlational relationships in data. Analyze and interpret data to provide evidence for phenomena.