# SCIENCE

(GRADES K-12)


**2015**

# Science
# Curriculum Guide

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## Philosophy Statement for Science

Morrison recognizes the universe as God's special creation and seeks to equip students to fulfill God's mandate (Gen 1:28). Science, as exemplified in the scientific method, is a process that enables all mankind to gain knowledge about creation, the laws that govern it, and the character of God. The end result of this process would be for each student to understand, appreciate, and be a good steward of God's creation.

Morrison's science program seeks to accomplish these goals by utilizing an activity-oriented program where teachers and students think analytically and logically, solve problems creatively, and use technology appropriately. Morrison endeavors to help students acquire developmentally appropriate concepts and science skills to make positive contributions from a Christian worldview in an increasingly scientific and technological society.

# Vision for Our Science Learners

## Moral and Ethical Citizen

1. Students will recognize the moral truths established by God as it pertains to the application of science and technology.
2. Students will have a moral and ethical base from which to decide how or whether to pursue scientific research / technology and how to apply what is discovered

## Spiritual Discerner

1. Students will recognize God as creator.
2. Students will recognize God's qualities through the natural world. (Rom. 1:20)
3. Students will understand that natural laws in science point them toward an understanding of God.
4. Students will accept their self-worth as God's creation.

## Critical and Creative Thinker

1. Students will use the scientific method to examine and investigate the empirical world.
2. Students will be able to analyze, interpret, evaluate, and synthesize concepts within various contexts.
3. Students will be able to discern reliability of scientific data.
4. Students will apply scientific learning in innovative and adaptive ways.

## Life-Long Learner

1. Students will recognize that scientists may have different perspectives of scientific theory.
2. Students will recognize and value science as an ongoing process and that concepts and knowledge change as new discoveries/updates are made.
3. Students will be equipped with various skills to update and apply their scientific knowledge.
4. Students will understand the need to adapt to new technology.

## Effective Communicator

1. Students can convey their scientific findings for various audiences using a variety of formats.
2. Students can effectively and respectfully articulate a Biblical worldview of scientific knowledge/theories/principles in response to differing perspectives.

## Wise and Responsible Steward

1. Students will recognize man's role in governing the natural world, as commissioned by God.
2. Students will take responsibility for the care of God's creation (personal health, the community, and the world).

# Hallmarks

## Biblical Worldview

How one perceives the physical universe directly impacts one's worldview. Christians who hold a biblical worldview sees God at work in the origins and continuance of the universe and of life itself (Genesis 1:1, Colossians 1:15-17). As God's creation, man is accountable for stewardship of the earth through discovery and innovation (Genesis 1:28). A science curriculum that carries the hallmark of being rooted in a biblical worldview will therefore feature a deep commitment to an interaction between science and faith where God has priority in our thinking.

Teachers of such a curriculum will:
1. Center their thinking on the authority of the biblical revelation.
- God is the Creator, a rational and intelligent Person
- Faith in God forms the basis for our belief system and lifestyle
- Careful investigation of Creation is encouraged and reveals the mind of God
- Scriptural truth matches scientific knowledge
- Encourage respectful discussion among those of differing worldviews
- Know that bias is a human problem and not a religious one

2. Embrace and practice science as a valid means of knowing
- Put a high premium on using the scientific method in an honest, unbiased way
- Search for truth in an open-ended manner, unrestricted by presuppositions
- Keep the flame of curiosity burning brightly
- Stay informed regarding recent discoveries and developments
- Science, as a way of knowing, has limitations

B*rand, Leonard, Professor of Biology and Paleontology at Loma Linda University, A Biblical Perspective on the Philosophy of Science accessed 4/21/0,*
http://www.grisda.org/origins/59006.pdf

## Cooperative Learning

Cooperative learning must be an intricate part in science classroom instruction at Morrison Academy. In the Morrison school system, cooperative learning can be seen as grouping students to accomplish two specific goals. First, grouping aids in making a smaller achievement gap between students through peer learning and full-class participation. Secondly, cooperative learning creates an environment that resembles real-life science investigation.

## Cultural Sensitivity

Cultural Sensitivity honors those we serve. As an international school in Taiwan, this means Morrison is mindful and responsive to the diverse cultural backgrounds and of students found in our schools. Therefore, the resources, instructional strategies, and assessment practices we employ address and appropriately adapt to the unique features of our student population.
For science, this includes being aware of students' cultural backgrounds, understanding how different learners construct knowledge, holding affirming views about diversity, and using appropriate instructional strategies. It is the science teachers ambition to provide for every student, regardless of cultural background, the opportunity to succeed and meet his or her potential in the sciences.

*Villegas, A.M. & Lucas T., The Culturally Responsive Teacher, Educational Leadership: March 2007, vol 63, no 6.*
*Jegede O.J. & Aikenhead G.S., Transcending Cultural Borders, accessed April 23, 2007,* http://www.ouhk.edu.hk/cridal/misc/jegede.htm

## Explicit Instruction with Hands-on Learning (Inquiry, Hands-on, and Discovery Learning)

Researchers have found hands-on learning is most beneficial when accompanied with direct instruction. If using only hands-on learning without direct instruction, difficulties can arise which include misinformation and gaps in feedback (David Klahr, PhD., psychology professor at Carnegie Mellon University). Benefits for students derived from direct instruction with hands-on learning are believed to include increased learning in the following areas:

- motivation to learn
- enjoyment of learning
- skill proficiency (including communication skills)
- independent thinking and decision making (based on direct evidence and experiences)
- perception and creativity

("Perspectives of Hands-On Science Teaching:" Question #2, Summary)

Technology can extend hands-on learning (without replacing the real life, activity-based approach) by allowing students to participate in non-traditional forms such as virtual learning. ("Perspectives of Hands-On Science Teaching," Question 1, p.2)

## Quality of Instruction

Instruction is most effective when it's personalized – when teachers sufficiently honor learners' interests, curiosity, strengths, contributions, and prior knowledge, making learners feel that they are an important part of something larger than themselves (Wiggins, McTighe, 2006) Morrison's Science teachers endeavor to choose instructional strategies that will maximize student learning. The suggestions from "Classroom Instruction that Works"[1] form the core that allow students in all grade levels to improve. They strive to develop life-long learners and problem-solvers thus teaching for meaning rather than just procedural answers. They lead class discussions with warranted open-ended questions, provide choices when appropriate, and engage students in movement at critical times during the lesson to help increase retention of the newly acquired information. The marriage of effective strategies with interesting and thought-provoking activities and experiments ensure student engagement. This engagement ultimately leads to improved achievement.

(Leinwand, Fleischman, 2004) (Jensen, 1998)

[1]Marzano, Robert J., Debra J. Pickering, Jane E. Pollock, Classroom instruction that works: Research-based strategies for increasing student achievement, ASCD, 2001

## Technology (in research, experimentation, and presentation)

The integration of technology (i.e. lab probes, computer simulations, Internet initiatives, microscope cameras, etc.) into the Morrison Science program is based on the premise that the use of technology will increase student learning.[1] When properly employed, the use of technology enhances the delivery of the curriculum. Students are "…more active participants in research and learning" and teachers have "…more flexibility in presentation, [and] better management of instructional techniques."[2]

[1]Crader, John, Far West Laboratory, Summary of Current Research and Evaluation Findings on Technology in Education, accessed 2/28/2007 at http://www.wested.org/techpolicy/refind.html.

[2]NSTA Position Statement, The Use of Computers in Science Education, accessed 3/12/2007, http://www.nsta.org/positionstatement&psid=4&print=y.

## The Impact of Positive Teacher/Student Relationships

The science program at Morrison Academy not only regards positive student/teacher relationships as a powerful factor in the promotion of the students' academic achievement and psychological adjustment, but also deems it vital because it is the essence of our call as Christian educators. Warm, caring teachers minimize the risk of social/emotional adjustment in students for learning to be optimized. At Morrison we pursue quality relationships with our students through lower class sizes and an emphasis on collaborative learning.

*Fredriksen, Katia and Rhodes, Jean, The Role of Teacher Relationships in the Lives of Students accessed 4/21/07,* http://www.pearweb.org/ndyd/pdfs/samplechapter.pdf

## Engaged Instructional Time Requirements

(Refer to Procedure 295)

## Strands: Kindergarten through Eighth Grade

The strands and benchmarks come from the California Next Generation Science Standards.

1 Physical Sciences
2 Life Sciences
3 Earth Sciences
4 Engineering Design

## Strands: High School

High school science strands are unique to each course offering.

# Scope and Sequence for Elementary Middle School

| | Earth Science | Life Science | Physical Science | Engineering Design |
|---|---|---|---|---|
| **K** | Earth's Systems (Weather)<br>Earth and Human Activity (Impact of Living Things) | From Molecules to Organisms: Structures and Processes (Needs of Living Things) | Motion and Stability: Forces and Interactions (Push and Pull)<br>Energy (Sun) | Engineering Design |
| **1st** | Earth's Place in the Universe (Sun, Moon, and Stars) | From Molecules to Organisms: Structures and Processes (Parts and Patterns of Living Things)<br>Heredity: Inheritance and Variation of Traits (Development of Living Things) | Waves and Their Applications in Technologies for Information Transfer (Light and Sound) | Engineering Design |
| **2nd** | Earth's Place in the Universe (Earth events)<br>Earth's Systems (Earth processes) | Ecosystems: Interactions, Energy, and Dynamics (Plant and Animal Interactions)<br>Origins and Diversity of Life (Habitats) | Matter and Its Interactions (Properties) | Engineering Design |
| **3rd** | Earth's Systems (Weather and Climate)<br>Earth and Human Activity (Impact of Weather Related Hazards) | From Molecules to Organisms: Structures and Processes (Life Cycles)<br>Ecosystems: Interactions, Energy, and Dynamics (Survival)<br>Heredity: Inheritance and Variation of Traits (Plant and Animal Traits)<br>Origins and Diversity of Life (Adaptations) | Motion and Stability: Forces and Interactions (Force, Motion, and Magnets) | Engineering Design |
| **4th** | Earth's Place in the Universe (Rocks and Fossils)<br>Earth's Systems (Effects of Weathering on Earth's Landforms)<br>Earth and Human Activity (Natural Resources and Natural Disasters) | From Molecules to Organisms: Structures and Processes (External and Internal Systems of Living Things) | Energy (Energy and its Transfer and Forms)<br>Waves and Their Applications in Technologies for Information Transfer (Waves and Patterns) | Engineering Design |
| **5th** | Earth's Place in the Universe (Patterns of the Sun and Other Stars)<br>Earth's Systems (Geosphere, Biosphere, Hydrosphere, and Atmosphere)<br>Earth and Human Activity (Conservation of Natural Resources) | From Molecules to Organisms: Structures and Processes (Plant Systems)<br>Ecosystems: Interactions, Energy, and Dynamics (Life Dependency and Interconnectivity) | Matter and Its Interactions (Chemical and Physical Changes)<br>Motion and Stability: Forces and Interactions (Gravity)<br>Energy (Food Chains) | Engineering Design |
| **6th** | Earth's Systems (Weather, climate)<br>Earth and Human Activity (Global temperature, human impact) | From Molecules to Organisms: Structures and Processes (Cell Structure, function and information processing)<br>Heredity: Inheritance and Variation of Traits (Mendelian genetics) | Energy (Energy transfer, heat) | Engineering Design |
| **7th** | Earth's Systems (Plate tectonics, rock cycle, weathering)<br>Earth and Human Activity (Resources, natural disasters) | From Molecules to Organisms: Structures and Processes (Photosynthesis, chemical reactions)<br>Ecosystems: Interactions, Energy, and Dynamics (Environmental interdependence, ecosystem) | Matter and Its Interactions (Atomic model, chemical and physical change, states of matter, conservation of mass) | Engineering Design |
| **8th** | Earth's Place in the Universe (Moon phases, gravity, geological time scale)<br>Earth and Human Activity (Sustainability) | Heredity: Inheritance and Variation of Traits (Genetic mutations)<br>Origins and Diversity of Life (Evolution, creation) | Motion and Stability: Forces and Interactions (Newton's laws of motion, forces, electromagnetic force, gravity)<br>Energy (Conservation of energy, kinetic and potential energy) | Engineering Design |

## Scope and Sequence for High School

2.0 credit units of Science including Biology and one other lab based science are required for graduation.

| ***Course*** | **Grade Level** | | | |
|---|---|---|---|---|
| | ***9th*** | ***10th*** | **11th** | **12th** |
| *Biology^* | | | | |
| *Chemistry** | | | | |
| *Human Anatomy** | | | | |
| *Physical Science* | | | | |
| *Physics** | | | | |
| *AP Biology** | | | | |
| *AP Chemistry** | | | | |

* Prerequisites apply.
^ Required for graduation

## Primary Resources for Instruction

### Elementary (K-5)

***National Geographic Learning Exploring Science ©2015***

| | |
|---|---|
| **Kindergarten:** | |
| Big Book Set | 978-13054-55375 |
| Teacher's Guide | 978-13051-09971 |
| **Grade 1:** | |
| Student Edition | 978-12858-46330 |
| Student eBook | 978-13050-86685 |
| Teacher's Guide | 978-13050-76914 |
| **Grade 2:** | |
| Student Edition | 978-12858-46347 |
| Student eBook | 978-13050-86692 |
| Teacher's Guide | 978-13050-76921 |
| **Grade 3:** | |
| Student Edition | 978-12858-46354 |
| Student eBook | 978-13050-86708 |
| Teacher's Guide | 978-13050-76938 |
| **Grade 4:** | |
| Student Edition | 978-12858-46361 |
| Student eBook | 978-13050-86715 |
| Teacher's Guide | 978-13050-76945 |
| **Grade 5:** | |
| Student Edition | 978-12858-46378 |
| Student eBook | 978-13050-86722 |
| Teacher's Guide | 978-13050-76952 |

### Middle School (6-8)

***Science Fusion Holt McDougal***

| | |
|---|---|
| TE MOD A 2012 | 978-054759383-8 |
| TCHR RES DVD EN/SP MOD A | 978-054759510-8 |
| TE MOD B 2012 | 978-054759381-4 |
| TCHR RES DVD EN/SP MOD B | 978-054759506-1 |
| TE MOD C 2012 | 978-054759385-2 |
| TCHR RES DVD EN/SP MOD C | 978-054759507-8 |
| TE MOD D 2012 | 978-054759380-7 |
| TCHR RES DVD EN/SP MOD D | 978-054759513-9 |
| TE MOD E 2012 | 978-054759387-6 |
| TCHR RES DVD EN/SP MOD E | 978-054759505-4 |
| TE MOD F 2012 | 978-054759388-3 |
| TCHR RES DVD EN/SP MOD F | 978-054759515-3 |
| TE MOD G 2012 | 978-054759377-7 |
| TCHR RES DVD EN/SP MOD G | 978-054761421-2 |

| | |
|---|---|
| TE MOD H 2012 | 978-054759382-1 |
| TCHR RES DVD EN/SP MOD H | 978-054759518-4 |
| TE MOD I 2012 | 978-054759393-7 |
| TCHR RES DVD EN/SP MOD I | 978-054759528-3 |
| TE MOD J 2012 | 978-054759390-6 |
| TCHR RES DVD EN/SP MOD J | 978-054759526-9 |
| TE MOD K 2012 | 978-054759394-4 |
| TCHR RES DVD EN/SP MOD K | 978-054759531-3 |

## High School

### Biology
*Holt, Rinehart and Winston, Modern Biology ©2009*
978-0-030-36769-4

### Chemistry
*Glencoe, Chemistry: Matter and Change ©2008*
978-0-078-74637-6

### Human Anatomy
*Pearson, Human Anatomy 7E plus Mastering AP with eText ©2014*
978-0-321-88428-2

### Physical Science
*Glencoe, Physical Science ©2012*
978-0-078-77962-6

### Physics
*Pearson, Conceptual Physics ©2015 Plus Mastering Physics with eText Access Card Package, 12/E*
*978-0-321-90860-5*
*Glencoe, Physics: Principles and Problems ©2009*
978-0-078-80721-3

### AP Biology
*Pearson, Biology 10th Edition (Campbell/Reece) ©2014*
*978-0-321-77565-8*

### AP Chemistry
*Pearson, Chemistry: The Central Science 11/E ©2007*
*978-0-136-00617-6*

# Overview by Grade/Course

## K-5 Program

### *Kindergarten*

Students will explore and analyze the effects of pushing and pulling objects in relation to force and motion. They will observe the sun, its effects and impact on life, and patterns of weather. Students will interact with and observe living things (animals and plants) to determine their needs, interaction with the environment, and impact on the environment. Using scientific processes, students will ask questions, make observations, and gather information to solve a simple problem. They will use simple sketches, drawings, or physical models to illustrate their learning.

### *Grade 1*

Students will analyze the effects of light and sound through exploration of waves. They will investigate how living things (animals and plants) use their parts to adapt, grow, and meet needs to survive. Students will identify, compare, and contrast patterns of animal and plant behavior from birth through maturity. They will observe the sun, the moon, and the stars to identify predictable patterns and relation to time. Using scientific processes, students will ask questions, make observations, and gather information to solve a simple problem. They will use simple sketches, drawings, or physical models to illustrate their learning.

### *Grade 2*

Students will determine the importance of sunlight and water on plant growth and the way plants and animals interact with pollination and seed dispersal. They will observe Earth events (processes) to determine that they can happen quickly or slowly and develop solutions to help prevent or slow these process. Students will observe and investigate matter and its interactions and changes. They will use scientific processes, students will ask questions, make observations, and gather information to solve a simple problem. They will use simple sketches, drawings, or physical models to illustrate their learning.

### *Grade 3*

Students will demonstrate knowledge of plants and animals in regards to life cycles and relationships to ecosystems. They will create graphic organizers and graphs to show knowledge of weather and climate. They will observe and investigate forces and motion, focusing on the interactions between them. They will use scientific processes to define a problem, compare possible solutions, and conduct experiments.

### *Grade 4*

Students will explore energy in its different forms. They will begin to build an understanding of how energy is transferred from one form to another. They will also consider how wave patterns are used in the transfer of information. Students will examine how an organism's internal and external structure support survival and help it process information from its environment. As they learn about Earth's systems, they investigate the properties of rocks and minerals and the causes that reshape Earth's landforms. Students are asked to consider meaningful questions and to build models, conduct investigations, and test their ideas through the scientific process.

*Grade 5*

Students will consider the structure of matter and how matter is conserved in spite of change resulting from it's heating, cooling, or mixing with other substances. They will also examine the force of gravity and the flow of energy from the sun through a food chain. They will learn about how plants get much of what the need from air and water. Students will build models to show how matter is transported through an ecosystem. They will also investigate Earth's relationship to the sun, the interactions of systems on the Earth, and the impact of human activity on its natural resources. Students will engage in the scientific process by asking meaningful questions and building models, conducting investigations, and testing their ideas.

## Middle School Program

Students will continue to learn aspects of earth, life, and physical science throughout middle school in an integrated fashion. Each grade level has curriculum benchmarks associated with each of the three sciences. In addition, there will be an emphasis on engineering design where students will create, test, and redesign models to explore concepts.

*Grade 6*

Students will focus on deepening their understanding of energy, weather, and cells as they develop their skills in engineering and design. In physical science, students will investigate energy transfer with an emphasis on heat. This understanding of energy will guide students into earth science as they consider weather and climate with an emphasis on how humans impact the environment. Finally, students will deepen their understanding of life science by studying cells and heredity.

*Grade 7*

Students will focus on understanding the relationship between energy and matter, specifying in how energy flows, drives cycles, and is conserved. Topics of study will include energy and matter flow in chemical reactions, photosynthesis, ecosystems, the rock cycle, and plate tectonics. Students will also examine the impact of unevenly distributed resources and of natural disasters.

*Grade 8*

Students will deepen their understanding of energy through mathematical relationships between energy, mass, velocity and position. Topics of study in physical science will include electromagnetic forces and motion. In life science, students will gain an understanding of the effect of genes and will examine the origins of life. Lastly in earth science, students will study the history of the Earth, its place in the Universe, and human impact on natural resources.

## High School Program

### *Biology*

This introductory course makes science more relevant for students and lays a foundation for future biology courses. It is the study of living things with comparisons of the basic animal and plant taxon.  Life processes will be studied as they apply to plants, animals, and humans. Class content gives the students a broad grasp of the meaning of life, and creation in God's design. This class is normally taken in 9th or 10th grade.

### *AP Biology*

This course is a comprehensive, in-depth investigation of modern biological principles in action at a university level. The course is designed for students pursuing careers in science or allied disciplines. There is a heavy emphasis on independent study, analysis of scientific journal articles, text readings, and writing critical laboratory reports. See AP courses policies in appendix.

Prerequisites: A minimum of a B in both Chemistry and Algebra II, and teacher (of those subjects) recommendation, Advanced Math and Physics recommended. Student course load and extracurricular involvement is also considered to insure that the prospective AP student has adequate time to commit to this course.

### *Chemistry*

This course addresses the composition, structure, and reactions of matter. The major emphasis is on inorganic compounds. A laboratory is coordinated to enhance understanding. The theoretical basis of concepts and their applications to a variety of written problems will be the major focus of the course with somewhat less emphasis on the application of concepts to contemporary life.

Prerequisite: Biology, B in Algebra 1or Physical Science.

*AP Chemistry*

This course meets all the depth and rigor of freshman chemistry at the college level. Topics covered are the structure of atoms, ions and molecules, mass relationships, chemical reaction, gases, thermochemistry, quantum theory, periodic relationships, bonding liquids and solids, kinetics, equilibrium, acids-base and solubility equilibrium, entropy, electrochemistry, metallurgy, and nuclear and organic chemistry. Students will further their skills and enhance understanding by work with corresponding labs and computer simulations. See AP courses policies in appendix.

Prerequisite: A minimum of a B in both Chemistry and Algebra II, and teacher (of those subjects) recommendation. Advanced Math is recommended.

*Human Anatomy and Physiology*

This advanced course is designed for students interested in the medical profession e.g. doctor, nurse, technician, physical therapy, geriatrics, and/or those desiring careers in the health or physical education areas. The eleven body systems are covered extensively with laboratory exercises to reinforce major concepts.

*Physical Science*

The intent of the course is to provide a basic background of physical sciences for students who want another year of Math before taking Chemistry. The topics covered are very similar to those in basic chemistry and physics but with a less rigorous application of algebra. This course will serve to prepare students for taking Chemistry.

*Physics*

This course studies force and motion, work and energy, electricity and magnetism, wave motions, sound and light, and electronics. A strong background in Algebra 1 and a good knowledge of Geometry and Right Triangle Trigonometry is assumed. This course is designed for 11th & 12th grade students.

Prerequisite: Geometry and Algebra 2

## Teaching About Creation, Evolution and the Age of the Earth

**NOTE:** The following section was slightly modified and inserted with permission from Delaware County Christian School Newtown Square, PA 19073

### Introduction

In our culture, there are two basic positions regarding ultimate reality and thus the origin of the universe. (Here and below, *universe*, *world*, and *nature* are used to refer to the sum total of all matter and energy in existence.) The first position is **theism**, which holds that the universe results from the action of a purposive supernatural being (God). The second position is **naturalism**, the belief that matter and energy are all that exist, or at least all that affect events in the universe. Naturalism holds that undirected, purposeless natural processes have accidentally resulted in the existence and characteristics of everything.

### The Primary Issue

Christian orthodoxy has always held that the God of the Bible is the ultimate cause of the universe around us; thus **all Christians agree that God made everything**. (The term *Christian* is used here to denote those who believe that the Bible is *inspired*—God's supernatural revelation to mankind—and who believe the historic creeds of the Christian church.) Christians agree that God made everything because the Bible clearly and repeatedly says so (e.g., Genesis 1:1, Exodus 4:11 & 20:11, Job 38:4, Proverbs 3:19, Isaiah 51:13, Jeremiah 32:17, Colossians 1:16, Hebrews 1:10, Revelation 14:7, and many other places). Christians also find support for this conviction from science. The more scientists learn about the structure and function of the universe, the more we appreciate the degree to which it is just right for the existence of human life.

**Consistent with Scripture and historic Christian belief, Morrison Academy insists that God made the universe**. The school teaches that the universe does not exist by accident, and that the better we understand its structure and function (which is the goal of science), the more impressed we will become with its Maker (Psalm 19:1, Proverbs 3:19).

### Secondary Issues

It is important to recognize that while Christians agree that God made everything, **we do not agree about exactly *how* and *when* God did it**. The most obvious reason is that the Bible speaks much less clearly and frequently about how and when God made everything, than of the fact that He did so. As a result, Christians reach different conclusions about what God is saying regarding the timing and method of creation. Christians also differ in their awareness of relevant scientific data, and in their convictions regarding how such data should be used to clarify their understanding of the Bible.

Virtually all Christians now believe that the earth orbits the sun, despite objections to this idea by such a hero of the faith as Martin Luther. Evidence from science eventually convinced us that we had *misunderstood* figurative Biblical language (such as references to the sun's rising and setting, and statements about the sun— not the earth—standing still in Joshua 10). However, Christians today have not reached consensus on whether we have misunderstood the *Bible*, the *scientific data*, or *both*, about how and when God created. The result of this disagreement is that Christians who believe in the inspiration of Scripture may be found in each of the following three camps: young-earth creationists, old-earth creationists, and theistic evolutionists.

At Morrison Academy, we believe that solving puzzles like how and when God created requires careful attention to both God's special revelation in the Bible and His general revelation in nature. **We teach our students that neither God's *Word* nor His *world* lie to us, although both can be misunderstood. Thus, accurately discerning *how* and *when* God made everything requires careful study of both the Bible and nature**. This is one reason why it is a high calling for Christian young people, confident of the Bible's reliability, to pursue training in the sciences.

**In light of the diversity of opinion among Christian Bible scholars and scientists regarding exactly how and when God created, Morrison chooses not to take an official position on either question. We emphasize that God made everything, but we do not require or expect students to accept a particular view of how or when God did it.** Younger students are taught that God is the maker of the universe, that we exist for a purpose, and that it is false to claim that life (or anything else) exists by accident. We do not consider specific arguments or teacher assertions for or against special creation, evolution, a young earth, or an old earth to be appropriate in the early grades. With younger students, we prefer to leave discussion of these matters to families and churches. In the elementary school library, we avoid stocking books that forcefully advocate a particular view of how or when God created, although passing references to these issues are unavoidable in books on some subjects. Older students are taught that naturalistic (i.e., impersonal, undirected, accidental) evolution is not Biblical, but that Christians hold a variety of other views on how and when God created. Without saying or implying that they should accept a particular view, we want our older students to understand the following positions: theistic (i.e., God-ordained) evolution, special creation, belief in a young earth (i.e., thousands of years old), and belief in an old earth (i.e., billions of years old).

## Four Christian Views On Origins

Much confusion surrounds origins issues. This is partly because terms are often used carelessly. The word *evolution*, for example, has so many meanings that it is almost useless. With this in mind, the sections below briefly describe four broad positions which Christians hold, and which we want our older students to understand. The descriptions below are generic; individuals within each group differ (sometimes widely) in their specific views.

Two Views on ***How*** God Made ***Living Things***

## Special Creation

**God created the basic kinds of living things by miracle. Since then, natural processes like genetic drift and natural selection have produced small changes in the original stock, resulting in *new varieties of the same basic kind of creature*.** For example, creationists believe that God miraculously created elephant-kind, and then the natural processes God built into nature produced African and Indian elephants (and perhaps mastodons and mammoths) from the original stock. The process of producing such minor variations in organisms is sometimes called *microevolution*. Creationists have no argument with this level of evolution. The many breeds of domestic dogs provide further examples of the result of microevolution: they are new varieties, but all are still dogs. Creationists believe that God has placed limits on how far natural change in organisms can go. Variation can occur *within a created kind*, but no new kinds will arise this way. For example, no matter how much time is available for variations to occur, no group of hoofed land mammals would ever give rise to anything as different as a whale. *Young-Earth* creationists believe that God made the basic kinds of organisms over a period of six 24-hour days, perhaps 10,000 years ago. *Old-Earth* creationists believe that God made them (by miracle) at various times over a period of several billion years. **Creationists do not agree about the age of the Earth.**

## Theistic Evolution

**Theistic evolution is *God-ordained evolution.*** Theistic evolutionists are convinced that God used a *process* and not *miracles* to make the major groups of creatures (this is what defines them as evolutionists and not creationists). *But theistic evolutionists reject the naturalistic idea that evolution is ultimately accidental and purposeless.* They believe that God very much gets credit for the existence of all creatures because *He invented* the process of evolution; it was *His tool* to bring about the living things *He wanted*.

Theistic evolutionists do not agree with those naturalistic evolutionists who claim that the evolutionary process makes belief in God unnecessary. Christian theistic evolutionists also disagree with those who deny the reality of miracles. They accept Jesus' virgin birth, His walking on water, His resurrection, etc. They believe in a miracle-working God, who for His own reasons chose to create living creatures using an evolutionary process. (Special creationists wonder why theistic evolutionists accept these miracles but do not accept miracles in creation.)

Thus, theistic and naturalistic evolutionists disagree about *why* evolution happens, but there is little disagreement between them about the general history of *how* living things have developed over the ages. The discussion below outlines the theory of evolution as a theistic evolutionist might explain it (i.e., God is given credit for the process).

**God used natural processes to eventually produce whole new basic kinds of creatures.** Unlike creationists, evolutionists do not believe that God imposed strict limits on natural change in living things. Given enough time (all evolutionists believe the old-earth view) and the right circumstances, a group of organisms can diversify into forms so different from the original stock that a whole new kind of creature has appeared. This production of a whole new kind of creature is called macroevolution. For example:

Evolutionists hold that variation in some fish gave rise to amphibians, variation in some amphibians produced reptiles, and variation in different groups of reptiles gave rise to mammals and birds. **Note that the evolution–creation debate is not about whether creatures change, but about *how far natural changes can go*. Creationists agree with microevolution but disagree with macroevolution.**

Evolutionists debate among themselves about exactly *how* macroevolution occurs. The standard textbook explanation used to be that *multitudes* of small changes (i.e., *lots and lots of* microevolution) gradually add up and result in the existence of a very different sort of creature than existed before. In other words, macroevolution is just the logical end product of micro-evolution carried on for a very long time. This model is sometimes called Darwinian evolution, since it reflects Charles Darwin's idea that evolution occurs in accumulated small steps.

However, most leading evolutionists today do not believe that the evidence supports strictly Darwinian evolution. They are committed evolutionists in that they believe *there are natural processes*—rather than a series of miracles—that explain the existence of modern living things. However, they do not think that accumulated microevolution is the sole cause of macroevolution. Research and debate continue as to what the processes behind macroevolution might be.

Obviously, any Christian view on origins must explain the first few chapters of Genesis. Christians who are theistic evolutionists have many different ideas about exactly what God is telling us in Genesis; some take the creation story as something like a parable. However, Morrison believes that Genesis clearly teaches the reality of an historical Adam, made sinless in God's image, who later sinned and brought judgment on humankind.

## Two Views on ***When*** God Made ***The Earth & Universe***

### Young-Earth View

(Also called Young-Universe, Recent-Creationism, Scientific Creationism, Flood Geology)

**God made everything in six 24-hour days, roughly 10,000 years ago. He used miracles (rather than natural processes He had set in place) to make the stars and planets. Many of the geological features on earth's surface appear to have taken millions of years to form, but are more accurately understood as effects of Noah's Flood. The Flood covered the entire planet, deposited most of earth's sedimentary rock layers, buried most of the fossils, and radically reshaped earth's surface.**

All who believe that earth is young are also creationists, since 10,000 years is not nearly enough time for evolution to have produced the living things on earth today. But many creationists do not hold a young-earth view.

Young-earth creationists are convinced that the early chapters of Genesis indicate a recent creation date, and believe that other interpretations (including those of old-earth creationists) compromise the reliability of Scripture. They consider the scientific arguments for billions of years of Earth and space history to be misleading. This might be because the evidence has been misinterpreted by scientists with a bias against Biblical truth and/or because scientists are wrongly assuming that studying present natural processes will tell us how events happened in the past … a past in which God did spectacular one-time miracles (e.g., creation, Noah's flood). The universe and Earth may thus *look old* in some ways, but not actually *be old.* This is a widespread view among evangelicals today. However, it is a minority view among scientists, including Christians who are scientists. This is especially true among scientists who deal directly with the evidence for the age of the earth and universe (e.g., geologists and astronomers).

### Old-Earth View

**God used natural processes to form the stars and planets, beginning about 14 billion years ago with the Big Bang. Earth is about 4.6 billion years old and the fossils were buried in separate local incidents over the last few billion years of that time.**

In response to accumulating evidence that earth was very old, the scientific community began to accept an ancient age for the earth before Darwin published his theory of evolution. **Most scientists today, both Christians and non-Christians, accept an age for the earth of billions of years. Some of these Christians are theistic evolutionists, but many are not. Many Christians who reject the theory of evolution accept an ancient earth; they are old-earth creationists.**

Christians who hold an old-earth view understand the early chapters of Genesis in various ways. As mentioned above, many *theistic evolutionists* take them figuratively. Many old-earth *creationists* take them literally, with the *days* in chapter one being understood in various ways: from very long periods of time, to 24-hour days in which God revealed the story to Moses. Although Christians who accept an ancient earth believe that young-earth creationists misunderstand the Bible regarding the creation date, both groups agree that the Bible is God's Word and that God is the maker of everything.

## Kindergarten Benchmarks

### 1 Physical Science

**Motion and Stability: Forces and Interactions**
K-PS2-1 I can plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
K-PS2-2 I can analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

**Energy**
K-PS3-1 I can make observations to determine the effect of sunlight on Earth's surface.
K-PS3-2 I can use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.

### 2 Life Science

**From Molecules to Organisms: Structures and Processes**
K-LS1-1 I can use observations to describe patterns of what plants and animals (including humans) need to survive.

### 3 Earth Science

**Earth's Systems**
K-ESS2-1 I can use and share observations of local weather conditions to describe patterns over time.
K-ESS2-2 I can construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

**Earth and Human Activity**
K-ESS3-1 I can use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.
K-ESS3-2 I can ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.
K-ESS3-3 I can communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

### 4 Engineering Design

K-2-ETS1-1 I can ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
K-2-ETS1-2 I can develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
K-2-ETS1-3 I can analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

# Grade 1 Benchmarks

## 1 Physical Science

**Waves and their Applications in Technologies for Information Transfer**
1-PS4-1 I can plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
1-PS4-2 I can make observations to construct an evidence-based account that objects can be seen only when illuminated.
1-PS4-3 I can plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.
1-PS4-4 I can use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

## 2 Life Science

**From Molecules to Organisms: Structures and Processes**
1-LS1-1 I can use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.
1-LS1-2 I can read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.

**Heredity: Inheritance and Variation of Traits**
1-LS3-1 I can make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

## 3 Earth Science

**Earth's Place in the Universe**
1-ESS1-1 I can use observations of the sun, moon, and stars to describe patterns that can be predicted.
1-ESS1-2 I can make observations at different times of year to relate the amount of daylight to the time of year.

## 4 Engineering Design

K-2-ETS1-1 I can ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
K-2-ETS1-2 I can develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
K-2-ETS1-3 I can analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

## Grade 2 Benchmarks

### 1 Physical Science

**Matter and its Interactions**
2-PS1-1 I can plan and conduct an investigation to describe and classify different kinds of materials by their observable properties
2-PS1-2 I can analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.*
2-PS1-3. I can make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
2-PS1-4. I can construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

### 2 Life Science

**Ecosystems: Interactions, Energy, and Dynamics**
2-LS2-1 I can plan and conduct an investigation to determine if plants need sunlight and water to grow.
2-LS2-2 I can develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.*

**Origins and Diversity of Life**
2-LS4-1 I can make observations of plants and animals to compare the diversity of life in different habitats.

### 3 Earth Science

**Earth's Place in the Universe**
2-ESS1-1 I can make observations from media to construct an evidence-based account that Earth events can occur quickly or slowly.

**Earth's Systems**
2-ESS2-1 I can compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.*
2-ESS2-2 I can develop a model to represent the shapes and kinds of land and bodies of water in an area.
2-ESS2-3 I can obtain information to identify where water is found on Earth and that it can be solid or liquid.

### 4 Engineering Design

K-2-ETS1-1 I can ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2 I can develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
3-5-ETS1-3 I can plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

# Grade 3 Benchmarks

## 1 Physical Science

**Motion and Stability: Forces and Interactions**
3-PS2-1 I can plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
3-PS2-2 I can make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
3-PS2-3 I can ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other
3-PS2-4 I can define a simple design problem that can be solved by applying scientific ideas about magnets.*

## 2 Life Science

**From Molecules to Organisms: Structures and Processes**
3-LS1-1 I can develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

**Ecosystems: Interactions, Energy, and Dynamics**
3-LS2-1 I can construct an argument that some animals form groups that help members survive.

**Heredity: Inheritance and Variation of Traits**
3-LS3-1 I can analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.
3-LS3-2 I can use evidence to support the explanation that traits can be influenced by the environment.

**Origins and Diversity of Life**
3-LS4-1 I can analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.
3-LS4-2 I can use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.
3-LS4-3 I can construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
3-LS4-4 I can make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*

## 3 Earth Science

**Earth's Systems**
3-ESS2-1 I can represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
3-ESS2-2 I can obtain and combine information to describe climates in different regions of the world.

**Earth and Human Activity**
3-ESS3-1 I can make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.*

## 4 Engineering Design

3-5-ETS1-1 I can define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2 I can generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3 I can plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

## Grade 4 Benchmarks

### 1 Physical Science

**Energy**
4-PS3-1 I can use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2 I can make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3 I can ask questions and predict outcomes about the changes in energy that occur when objects collide.
4-PS3-4 I can apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*

**Waves and their Applications in Technologies for Information Transfer**
4-PS4-1 I can develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.
4-PS4-2 I can develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.
4-PS4-3 I can generate and compare multiple solutions that use patterns to transfer information.

### 2 Life Science

**From Molecules to Organisms: Structures and Processes**
4-LS1-1 I can construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
4-LS1-2 I can use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

### 3 Earth Science

**Earth's Place in the Universe**
4-ESS1-1 I can identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

**Earth's Systems**
4-ESS2-1 I can make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
4-ESS2-2 I can analyze and interpret data from maps to describe patterns of Earth's features.

**Earth and Human Activity**

4-ESS3-1 I can obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
4-ESS3-2 I can generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*

## 4 Engineering Design

3-5-ETS1-1 I can define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2 I can generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3 I can plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

# Grade 5 Benchmarks

## 1 Physical Science

**Matter and Its Interactions**
5-PS1-1 I can develop a model to describe that matter is made of particles too small to be seen.
5-PS1-2 I can measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
5-PS1-3 I can make observations and measurements to identify materials based on their properties.
5-PS1-4 I can conduct an investigation to determine whether the mixing of two or more substances results in new substances.

**Motion and Stability: Forces and Interactions**
5-PS2-1 I can support an argument that the gravitational force exerted by Earth on objects is directed down.

**Energy**
5-PS3-1 I can use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

## 2 Life Science

**From Molecules to Organisms: Structures and Processes**
5-LS2-1 I can support an argument that plants get the materials they need for growth chiefly from air and water.

**Ecosystems: Interactions, Energy, and Dynamics**
5-LS2-2 I can develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

## 3 Earth Science

**Earth's Place in the Universe**
5-ESS1-1 I can support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth.
5-ESS1-2 I can represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

**Earth's Systems**
5-ESS2-1 I can develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
5-ESS2-2 I can describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

**Earth and Human Activity**
5-ESS3-1 I can obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

## 4 Engineering Design

3-5-ETS1-1 I can define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2 I can generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3. I can plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

# Grade 6 Benchmarks

## 1 Physical Science

**Energy**
MS-PS3-3. I can apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
MS-PS3-4. I can plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
MS-PS3-5. I can construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

## 2 Life Science

**Structure, Function and Information Processing**
MS-LS1-1.I can conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
MS-LS1-2.I can develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
MS-LS1-3. I can use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
MS-LS1-8. I can gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
**Growth, Development, and Reproduction of Organisms**
MS-LS1-4. I can use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
MS-LS1-5. I can construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-LS3-2. I can develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

## 3 Earth Science

**Earth's System**

MS-ESS2-4. I can develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
MS-ESS2-5. I can collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

MS-ESS2-6. I can develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

**Earth and Human Activity**
MS-ESS3-3. I can apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
MS-ESS3-5. I can ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

## 4 Engineering Design

MS-ETS1-1. I can define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. I can evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. I can analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. I can develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

# Grade 7 Benchmarks

## 1 Physical Science

**Matter and Its Interactions**
MS-PS1-1. I can develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-2. I can analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
MS-PS1-3. I can gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS1-4. I can develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
MS-PS1-5. I can develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
MS-PS1-6. I can undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

## 2 Life Science

**From Molecules to Organisms: Structures and Processes**
MS-LS1-6. I can construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
MS-LS1-7. I can develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

**Ecosystems: Interactions, Energy, and Dynamics**
MS-LS2-1. I can analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-2. I can construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
MS-LS2-3. I can develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-LS2-4. I can construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-5. I can evaluate competing design solutions for maintaining biodiversity and ecosystem services.

# 3 Earth Science

**Earth's Systems**

MS-ESS2-1. I can develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

MS-ESS2-2. I can construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

MS-ESS2-3. I can analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

**Earth and Human Activity**

MS-ESS3-1. I can construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

MS-ESS3-2. I can analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

# 4 Engineering Design

MS-ETS1-1. I can define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. I can evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. I can analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. I can develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

# Grade 8 Benchmarks

## 1 Physical Science

**Motion and Stability: Forces and Interactions**
MS-PS2-1. I can apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2. I can plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS2-3. I can ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-4. I can construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
MS-PS2-5. I can conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

**Energy**
MS-PS3-1. I can construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-2. I can develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

## 2 Life Science

**Heredity: Inheritance and Variation of Traits**
MS-LS3-1. I can develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

**Origins and Diversity of Life**
MS-LS4-1. I can analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2. I can apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
MS-LS4-4. I can construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-5. I can gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

MS-LS4-7* I can construct a viewpoint on the origins of life based on the evidence provided for evolution and creation, taking into account the different views of creation.

**Benchmark specific to Morrison Academy*

## 3 Earth Science

**Earth's Place in the Universe**
MS-ESS1-1. I can develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
MS-ESS1-2. I can develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
MS-ESS1-3. I can analyze and interpret data to determine scale properties of objects in the solar system.
MS-ESS1-4. I can construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

**Earth and Human Activity**
MS-ESS3-4. I can construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

## 4 Engineering Design

MS-ETS1-1. I can define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. I can evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. I can analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. I can develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

# Biology

## 1 Biological Principles

*The student will understand the basic concepts about the structure and properties of matter.*

a. I know the major themes of biology and the subfields of biological studies
b. I can use the basic skills of scientific study, including measurement and use of tools, as well as scientific procedures included in the Scientific Method.
c. I have knowledge of the basic concepts of chemistry as they relate to biological sciences including the basic structure and function of the major macromolecules of life.

## 2 Cells

*The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept:*

a. I can understand basic cell theory and the differences between Prokaryotic and Eukaryotic cells.
b. I can understand the structure and function of the basic cell organelles.
c. I can understand the processes of homeostasis and cell transport and the role they play in the functioning of organisms.
d. I can understand the processes of photosynthesis and cell respiration and the role they play in the functioning of organisms.
e. I can understand the processes of Mitosis and Meiosis.

## 3 Genetics and the Origin of Life

*Mutation and sexual reproduction lead to genetic variation in a population. As a basis for understanding this concept:*

a. I can understand the basic concepts of Mendelian genetics including dominant and recessive traits, genotype and phenotype prediction and the laws of segregation and independent assortment.
b. I can know the structure of DNA and understand the process by which proteins are synthesized and the roles DNA and RNA play in that process
c. I can understand the process by which traits are inherited and the effect that mutations have on the expression of those traits.
d. I can understand the tools and technologies that are used to predict and manipulate genetic expression and how these are applied in the fields of biotechnology

## 4 Origins and Diversity of Life

*The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. As a basis for understanding this concept:*

a. I can understand the different viewpoints, both naturalistic and theistic, of the origins of the universe and life.
b. I can understand Darwin's theories of evolution and natural selection.
c. I am familiar with evidence supporting a Christian view of the diversity of life.
d. I can understand the diversity of life through a study of the domains and kingdoms.

## 5 Ecology

*Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:*

a. I can understand that all factors (biotic and abiotic) of an ecosystem are linked through the cycling of energy and materials.
b. I can understand the basic principles of population study including population measurement, density and fluctuation cycles.
c. I can understand that populations interact in a variety ways within communities and those communities can change over time.
d. I can understand the diversity of ecosystems present in our world.
e. I can understand the effects of human interactions with the natural world.

## 6 Human Body Systems

*As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment. As a basis for understanding this concept:*

a. I understand the structure and function of human body systems.

## Chemistry

### 1 Atomic and Molecular Structure

*The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:*

a. I know that most elements have two or more isotopes (i.e. atoms that differ in the number of neutrons in the nucleus); although the number of neutrons has little effect on how the atom interacts with other atoms, it does affect the mass and stability of the nucleus.
b. I can explain trends in ionization energy, electronegativity, and the relative sizes of atoms.
c. I know how to relate the position of an element in the periodic table to its quantum electron configuration, bonding capabilities, and to its reactivity with other elements in the table.
d. I know the experimental basis for the various models of the atom (e.g. Dalton, Thomson, Rutherford, Bohr, Quantum Mechanical).
e. I can explain the cause of spectral lines and perform calculations about them.
f. I know the types and characteristics of radioactive decay

### 2 Chemical Bonds

*Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:*

a. I know the types and characteristics of crystals produced in ionic and covalent structures.
b. I know the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.
c. I know how to draw Lewis dot structures and can use the structures to predict the shape of simple molecules and their polarity.

### 3 Conservation of Matter and Stoichiometry

*The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants. As a basis for understanding this concept:*

a. I know how to describe chemical reactions by writing balanced equations.

b. I know the quantity one mole is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams and contains $6.02 \times 10^{23}$ particles (atoms or molecules).
c. I know how to perform stoichiometry calculations.
d. I know how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions.

## 4 Gases and Their Properties

*The kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. As a basis for understanding this concept:*

a. I can use the Kinetic Molecular Theory to explain the characteristics of gases.
b. I know how to solve problems by using the ideal gas law in the form $PV = nRT$.

## 5 Acids and Bases

*Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:*

a. I know the Arrhenius, Brønsted-Lowry, and Lewis acid-base definitions.
b. I know strong acids and bases fully dissociate and weak acids and bases partially dissociate.
c. I know how to calculate pH from the hydrogen-ion concentration.
d. I know buffers resist changes in pH in acid-base reactions.

## 6 Solutions

*Solutions are homogeneous mixtures of two or more substances. As a basis for understanding this concept:*

a. I know temperature, pressure, and surface area affect the dissolving process.
b. I know how to calculate the concentration of a solute in terms and molarity.
c. I know the relationship between the molality of a solute in a solution and the solution's depressed freezing point or elevated boiling point.
d. I know how molecules in a solution are separated or purified by the methods of chromatography and distillation.

## 7 Reaction Rates

*Chemical reaction rates depend on factors that influence the frequency of collision of reactant molecules. As a basis for understanding this concept:*

a. I know the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.
b. I know how reaction rate depends on such factors as concentration, temperature, and pressure.
c. I know the role a catalyst plays in increasing the reaction rate.
d. I know the definition and role of activation energy in a chemical reaction.

## 8 Chemical Equilibrium

*Chemical equilibrium is a dynamic process at the molecular level. As a basis for understanding this concept:*

a. I know how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature, and pressure.
b. I know equilibrium is established when forward and reverse reaction rates are equal.
c. I know how to write and can calculate an equilibrium constant expression for a reaction.

## 9 Chemical Thermodynamics

*Energy is exchanged or transformed in all chemical reactions and physical changes of matter. As a basis for understanding this concept:*

a. I know how to describe temperature and heat flow in terms of the motion of molecules (or atoms).
b. I know energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.
c. I know how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.
d. I know how to apply Hess's law to calculate enthalpy change in a reaction.
e. I know how to use the Gibbs free energy equation to determine whether a reaction would be spontaneous.

## 10 Investigation and Experimentation

a. I can select and use appropriate tools and technology (e.g. computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
b. I can identify and communicate sources of unavoidable experimental error.
c. I can identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
d. I can formulate explanations by using logic and evidence.
e. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.
f. I can distinguish between hypothesis and theory as scientific terms.
g. I can recognize the usefulness and limitations of models and theories as scientific representations of reality.
h. I can analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
i. I can recognize the issues of statistical variability and the need for controlled tests.
j. I can recognize the cumulative nature of scientific evidence.
k. I can analyze situations and solve problems that require combining and applying concepts from more than one area of science.
l. I can investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions.
m. I know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e.g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).

## 11 Connections

a. I can analyze the benefits, limitations, costs, and consequences involved in using technology or resources. (e.g. X-rays, agricultural chemicals, natural gas reserves)
b. I can analyze how the introduction of a new technology has affected or could affect human activity. (e.g. invention of the telescope, applications of modern telecommunications)
c. I can demonstrate the interrelationships between science and technology. (e.g. building a bridge, designing a better running shoe)
d. I can explain the use of technology in an occupation.
e. I investigate careers based in the use of science and technology.
f. I apply my knowledge and understanding of chemical and physical interactions to explain present and anticipated technologies. (e.g. lasers, ultrasound,

superconducting materials, photocopy machines)

g. I can explore the scientific and technological aspects of contemporary problems. (e.g. issues related to nutrition, air quality, natural resources).
h. I can evaluate print and visual media for scientific evidence, bias, or opinion.
i. I can explain that the scientific way of knowing uses a critique and consensus process. (e.g. peer review, openness to criticism, logical arguments, skepticism)
j. I can use graphs, equations, or other models to analyze systems involving change and constancy. (e.g. comparing the geologic time scale to shorter time frames)
k. I can analyze and compare models of cyclic change as used within and among scientific disciplines. (e.g. water cycle, circular motion, sound waves, weather cycles, equilibrium)
l. I can identify and describe the dynamics of natural systems. (e.g. weather systems, ecological systems, body systems, systems at dynamic equilibrium)
m. I can analyze a model of a system involving change and constancy. (e.g. a mathematical expression for gas behavior; constructing a closed ecosystem such as an aquarium)

# Human Anatomy

## 1 Body Organization

a. I have a working knowledge of body organization.
b. I understand the chemical basis of the body.
c. I can describe the structure and function of a cell.
d. I can describe the structure and function of a tissue.
e. I can describe the organs and systems of the body.

## 2 Support/Cover/Movement Systems

a. I can describe the structure and function of the skeletal system.
b. I can describe the structure and function of the integumentary system.
c. I can describe the structure and functions of the muscular system.

## 3 Communication Systems

a. I can describe the structure and function of the nervous system.
b. I can identify the special senses and their functions.
c. I can describe the general structures and functions of the endocrine system.

## 4 Transport/Protect Systems

a. I can describe the structure and functions of the blood.
b. I can describe the structure and functions of the cardiovascular system.
c. I can describe the structure and functions of the lymphatic system.

## 5 Metabolic Processes

a. I can describe the structures and functions of the respiratory system.
b. I can describe the structures and functions of the digestive system.
c. I can describe concepts of nutrition.
d. I can describe the key structures and functions of the urinary system.

## 6 Human Development

a. I can describe the structures and functions of the male and female reproductive systems.
b. I can describe the stages of embryonic development and birth events.

## Physical Science

Refer to Appendix B for Extended Physical Science benchmarks.

### 1 Motion and Forces

a. I can distinguish between, and solve problems involving, velocity, speed, and constant acceleration.
b. I can apply Newton's Laws to solve motion problems..
c. I know the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth. .
d. I know Newton's laws are not exact but provide very good approximations unless an object is moving close to the speed of light or is small enough that quantum effects are important.

### 2 Conservation of Energy and Momentum

a. I can solve problems involving conservation of energy in simple systems, such as falling objects.
b. I can solve problems involving elastic and inelastic collisions in one dimension by using the principles of conservation of momentum and energy.

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### 3 Heat and Thermodynamics

a. I know heat flow and work are two forms of energy transfer between systems. .
b. I know and can explain how heat flow affects phase changes.
c. I know that entropy is a quantity that measures the order or disorder of a system and that most processes tend towards disorder..

### 4 Waves

a. I know waves carry energy from one place to another without the transfer of matter.
b. I can identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
c. I can solve problems involving wavelength, frequency, and wave speed.
d. I know sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.
e. I can recognize the characteristics of a standing wave and explain how it forms.
f. I know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately $3 \times 10^8$ m/s (186,000 miles/second).
g. I can identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.
h. I know light color depends upon the wavelength of the electromagnetic wave.

### 5 Electric and Magnetic Phenomena

a. I can predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.
b. I can solve problems involving Ohm's law.
c. I know any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula Power = VI (potential difference) × I (current) = $I^2R = V^2/R$.
d. I know charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.

## 6 Atomic and Molecular Structure

a. I can relate the position of an element in the periodic table to its atomic number and atomic mass. I can use the periodic table to identify metals, semimetals, nonmetals, and halogens. I can use the periodic table to determine the number of electrons available for bonding.
b. I can use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electronegativity, and the relative sizes of ions and atoms.

## 7 Investigation and Experimentation

a. I can use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
b. I can identify and communicate sources of unavoidable experimental error. I can identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
c. I can recognize the issues of statistical variability and the need for controlled tests.
d. I can formulate explanations by using logic and evidence.
e. I can distinguish between hypothesis and theory as scientific terms.
f. I can recognize the usefulness and limitations of models and theories as scientific representations of reality.

## Physics Benchmarks

### Characteristics of Science: Habits of Mind

a. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
b. Students will use standard safety practices for all classroom laboratory and field investigations.
c. Students will identify and investigate problems scientifically.
d. Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.
e. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.
f. Students will communicate scientific investigations and information clearly.

### Characteristics of Science: The Nature of Science

a. Students will analyze how scientific knowledge is developed.

### Content: Force, Mass, Gravity, and the Motion of Objects

a. I can calculate average velocity, instantaneous velocity, and acceleration in a given frame of reference.
b. I can compare and contrast scalar and vector quantities.
c. I can compare graphically and algebraically the relationships among position, velocity, acceleration, and time.
d. I can measure and calculate the magnitude of frictional forces and Newton's three Laws of Motion.
e. I can measure and calculate the magnitude of gravitational forces.
f. I can measure and calculate two-dimensional motion (projectile and circular) by using component vectors.
g. I can measure and calculate centripetal force.
h. I can determine the conditions required to maintain a body in a state of static equilibrium.

### Content: Significance of energy in Structure of Matter and the Universe

a. I can relate the energy produced through fission and fusion by stars as a driving force in the universe.
b. I can explain how the instability of radioactive isotopes results in spontaneous nuclear reactions.

### Content: Forms and Transformations of Energy

a. I can analyze, evaluate, and apply the principle of conservation of energy and measure the components of work-energy theorem by
    - describing total energy in a closed system.
    - identifying different types of potential energy.
    - calculating kinetic energy given mass and velocity.
    - relating transformations between potential and kinetic energy.
b. I can explain the relationship between matter and energy.
c. I can measure and calculate the vector nature of momentum.

d. I can compare and contrast elastic and inelastic collisions.
e. I can demonstrate the factors required to produce a change in momentum.
f. I can analyze the relationship between temperature, internal energy, and work done in a physical system.

**Content: Properties and Applications of Waves**

a. I can explain the processes that results in the production and energy transfer of electromagnetic waves.
b. I can experimentally determine the behavior of waves in various media in terms of reflection, refraction, and diffraction of waves.
c. I can explain the relationship between the phenomena of interference and the principle of superposition.
d. I can demonstrate the transfer of energy through different mediums by mechanical waves.
e. I can determine the location and nature of images formed by the reflection or refraction of light.

**Content: Electrical and Magnetic Forces**

a. I can describe the transformation of mechanical energy into electrical energy and the transmission of electrical energy.
b. I can determine the relationship among potential difference, current, and resistance in a direct current circuit.
c. I can determine equivalent resistances in series and parallel circuits.
d. I can determine the relationship between moving electric charges and magnetic fields.

**Content: Quantum Mechanics and Relativity**

a. I can explain matter as a particle and as a wave.
b. I can describe the Uncertainty Principle.
c. I can explain the differences in time, space, and mass measurements by two observers when one is in a frame of reference moving at constant velocity parallel to one of the coordinate axes of the other observer's frame of reference if the constant velocity is greater than one tenth the speed of light.
d. I can describe the gravitational field surrounding a large mass and its effect on a ray of light.

## Advanced Placement Biology

### Big Idea 1: The process of evolution drives the diversity and unity of life.

*Essential Knowledge:*

1.A.1: Natural selection is a major mechanism of evolution.
1.A.2: Natural selection acts on phenotypic variations in populations.
1.A.3: Evolutionary change is also driven by random processes.
1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.
1.C.1: Speciation and extinction have occurred throughout the Earth's history.
1.C.2: Speciation may occur when two populations become reproductively isolated from each other.
1.C.3: Populations of organisms continue to evolve.
1.D.1: There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.

### Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostastis.

*Essential Knowledge:*

2.A.1: All living systems require constant input of free energy.
2.A.2: Organisms capture and store free energy for use in biological processes.
2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
2.B.1: Cell membranes are selectively permeable due to their structure.
2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.
2.C.2: Organisms respond to changes in their external environments.
2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.

2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.
2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.
2.D.4: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.
2.E.1: Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.
2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.
2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.

**Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.**

*Essential Knowledge:*

3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
3.A.2: In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.
3.A.3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
3.A.4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
3.B.1: Gene regulation results in differential gene expression, leading to cell specialization.
3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression.
3.C.1: Changes in genotype can result in changes in phenotype.
3.C.2: Biological systems have multiple processes that increase genetic variation.
3.C.3: Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.
3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.
3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.
3.D.3: Signal transduction pathways link signal reception with cellular response.
3.D.4: Changes in signal transduction pathways can alter cellular response.
3.E.1: Individuals can act on information and communicate it to others.
3.E.2: Animals have nervous systems that detect external and internal signals,

transmit and integrate information, and produce responses.

**Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.**

*Essential Knowledge:*

4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.
4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.
4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.
4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.
4.A.5: Communities are composed of populations of organisms that interact in complex ways.
4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.
4.B.1: Interactions between molecules affect their structure and function.
4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.
4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.
4.B.4: Distribution of local and global ecosystems changes over time.
4.C.1: Variation in molecular units provides cells with a wider range of functions.
4.C.2: Environmental factors influence the expression of the genotype in an organism.
4.C.3: The level of variation in a population affects population dynamics.
4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.

## Science Practices (SP)

a. The student can use representations and models to communicate scientific phenomena and solve scientific problems.
b. The student can use mathematics appropriately.
c. The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.
d. The student can plan and implement data collection strategies appropriate to a particular scientific question.
e. The student can perform data analysis and evaluation of evidence.
f. The student can work with scientific explanations and theories.
g. g. The student is able to connect and relate knowledge across various scales,

concepts and representations in and across domains.

## Advanced Placement Chemistry

### Big Idea 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions.

*Essential Knowledge:*

1.A.1: Molecules are composed of specific combinations of atoms; different molecules are composed of combinations of different elements and of combinations of the same elements in differing amounts and proportions.
1.A.2: Chemical analysis provides a method for determining the relative number of atoms in a substance, which can be used to identify the substance or determine its purity.
1.A.3: The mole is the fundamental unit for counting numbers of particles on the macroscopic level and allows quantitative connections to be drawn between laboratory experiments, which occur at the macroscopic level, and chemical processes, which occur at the atomic level.
1.B.1: The atom is composed of negatively charged electrons, which can leave the atom, and a positively charged nucleus that is made of protons and neutrons. The attraction of the electrons to the nucleus is the basis of the structure of the atom. Coulomb's law is qualitatively useful for understanding the structure of the atom.
1.B.2: The electronic structure of the atom can be described using an electron configuration that reflects the concept of electrons in quantized energy levels or shells; the energetics of the electrons in the atom can be understood by consideration of Coulomb's law.
1.C.1: Many properties of atoms exhibit periodic trends that are reflective of the periodicity of electronic structure.
1.C.2: The currently accepted best model of the atom is based on the quantum mechanical model.
1.D.1: As is the case with all scientific models, any model of the atom is subject to refinement and change in response to new experimental results. In that sense, an atomic model is not regarded as an exact description of the atom, but rather a theoretical construct that fits a set of experimental data.
1.D.2: An early model of the atom stated that all atoms of an element are identical. Mass spectrometry data demonstrate evidence that contradicts this early model.
1.D.3: The interaction of electromagnetic waves or light with matter is a powerful means to probe the structure of atoms and molecules, and to measure their concentration.
1.E.1: Physical and chemical processes can be depicted symbolically; when this is done, the illustration must conserve all atoms of all types.
1.E.2: Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances,
and the amount of these depends on the number and the types and masses of elements in the reactants, as well as the efficiency of the transformation.

### Big Idea 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.

*Essential knowledge:*
2.A.1: The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures.
2.A.2: The gaseous state can be effectively modeled with a mathematical equation relating various macroscopic properties. A gas has neither a definite volume nor a definite shape; because the effects of attractive forces are minimal, we usually assume that the particles move independently.
2.A.3: Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of the solutes and solvent.
2.B.1: London dispersion forces are attractive forces present between all atoms and molecules. London dispersion forces are often the strongest net intermolecular force between large molecules.
2.B.2: Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force that exists when very electronegative atoms (N, O, and F) are involved.
2.B.3: Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions.
2.C.1: In covalent bonding, electrons are shared between the nuclei of two atoms to form a molecule or polyatomic ion. Electronegativity differences between the two atoms account for the distribution of the shared electrons and the polarity of the bond.
2.C.2: Ionic bonding results from the net attraction between oppositely charged ions, closely packed together in a crystal lattice.
2.C.3: Metallic bonding describes an array of positively charged metal cores surrounded by a sea of mobile valence electrons.
2.C.4: The localized electron bonding model describes and predicts molecular geometry using Lewis diagrams and the VSEPR model.
2.D.1: Ionic solids have high melting points, are brittle, and conduct electricity only when molten or in solution.
2.D.2: Metallic solids are good conductors of heat and electricity, have a wide range of melting points, and are shiny, malleable, ductile, and readily alloyed.
2.D.3: Covalent network solids generally have extremely high melting points, are hard, and are thermal insulators. Some conduct electricity.
2.D.4: Molecular solids with low molecular weight usually have low melting points and are not expected to conduct electricity as solids, in solution, or when molten.

## Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.

*Essential knowledge:*
3.A.1: A chemical change may be represented by a molecular, ionic, or net ionic equation.
3.A.2: Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists.
3.B.1: Synthesis reactions are those in which atoms and/or molecules combine to form a new compound. Decomposition is the reverse of synthesis, a process whereby molecules are decomposed, often by the use of heat.
3.B.2: In a neutralization reaction, protons are transferred from an acid to a base.

3.B.3: In oxidation-reduction (redox) reactions, there is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced.
3.C.1: Production of heat or light, formation of a gas, and formation of a precipitate and/or a color change are possible evidences that a chemical change has occurred.
3.C.2: Net changes in energy for a chemical reaction can be endothermic or exothermic.
3.C.3: Electrochemistry shows the interconversion between chemical and electrical energy in galvanic and electrolytic cells.

**Big Idea 4: Rates of chemical reactions are determined by details of the molecular collisions.**

*Essential knowledge:*

4.A.1: The rate of a reaction is influenced by the concentration or pressure of reactants, the phase of the reactants and products, and environmental factors such as temperature and solvent.
4.A.2: The rate law shows how the rate depends on reactant concentrations.
4.A.3: The magnitude and temperature dependence of the rate of reaction is contained quantitatively in the rate constant.
4.B.1: Elementary reactions can be unimolecular or involve collisions between two or more molecules.
4.B.2: Not all collisions are successful. To get over the activation energy barrier, the colliding species need sufficient energy. Also, the orientations of the reactant molecules during the collision must allow for the rearrangement of reactant bonds to form product bonds.
4.B.3: A successful collision can be viewed as following a reaction path with an associated energy profile.
4.C.1: The mechanism of a multistep reaction consists of a series of elementary reactions that add up to the overall reaction.
4.C.2: In many reactions, the rate is set by the slowest elementary reaction, or rate-limiting step.
4.C.3: Reaction intermediates, which are formed during the reaction but not present in the overall reaction, play an important role in multistep reactions.
4.D.1: Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism, and by providing a new and faster reaction mechanism.
4.D.2: Important classes in catalysis include acid-base catalysis, surface catalysis, and enzyme catalysis.

**Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.**

*Essential knowledge:*

5.A.1: Temperature is a measure of the average kinetic energy of atoms and molecules.
5.A.2: The process of kinetic energy transfer at the particulate scale is referred to in this course as heat transfer, and the spontaneous direction of the transfer is always from a hot to a cold body.
5.B.1: Energy is transferred between systems either through heat transfer or through one system doing work on the other system.
5.B.2: When two systems are in contact with each other and are otherwise isolated, the energy that comes out of one system is equal to the energy that goes into the other system. The combined energy of the two systems remains fixed. Energy transfer can occur through either heat exchange or work.
5.B.3: Chemical systems undergo three main processes that change their energy:

heating/cooling, phase transitions, and chemical reactions.
5.B.4: Calorimetry is an experimental technique that is used to determine the heat exchanged/transferred in a chemical system.
5.C.1: Potential energy is associated with a particular geometric arrangement of atoms or ions and the electrostatic interactions between them.
5.C.2: The net energy change during a reaction is the sum of the energy required to break the bonds in the reactant molecules and the energy released in forming the bonds of the product molecules. The net change in energy may be positive for endothermic reactions where energy is required, or negative for exothermic reactions where energy is released.
5.D.1: Potential energy is associated with the interaction of molecules; as molecules draw near each other, they experience an attractive force. 5.D.2: At the particulate scale, chemical processes can be distinguished from physical processes because chemical bonds can be distinguished from intermolecular interactions.
5.D.3: Noncovalent and intermolecular interactions play important roles in many biological and polymer systems.
5.E.1: Entropy is a measure of the dispersal of matter and energy.
5.E.2: Some physical or chemical processes involve both a decrease in the internal energy of the components ($\Delta H° < 0$) under consideration and an increase in the entropy of those components ($\Delta S° > 0$). These processes are necessarily "thermodynamically favored" ($\Delta G° < 0$).
5.E.3: If a chemical or physical process is not driven by both entropy and enthalpy changes, then the Gibbs free energy change can be used to determine whether the process is thermodynamically favored.
5.E.4: External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive.
5.E.5: A thermodynamically favored process may not occur due to kinetic constraints (kinetic vs. thermodynamic control).

**Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.**

*Essential knowledge:*
6.A.1: In many classes of reactions, it is important to consider both the forward and reverse reaction.
6.A.2: The current state of a system undergoing a reversible reaction can be characterized by the extent to which reactants have been converted to products. The relative quantities of reaction components are quantitatively described by the reaction quotient, Q.
6.A.3: When a system is at equilibrium, all macroscopic variables, such as concentrations, partial pressures, and temperature, do not change over time. Equilibrium results from an equality between the rates of the forward and reverse reactions, at which point $Q = K$.
6.A.4: The magnitude of the equilibrium constant, K, can be used to determine whether the equilibrium lies toward the reactant side or product side.
6.B.1: Systems at equilibrium respond to disturbances by partially countering the effect of the disturbance (Le Chatelier's principle).
6.B.2: A disturbance to a system at equilibrium causes Q to differ from K, thereby taking the system out of the original equilibrium state. The system responds by bringing Q back into agreement with K, thereby establishing a new equilibrium state.

6.C.1: Chemical equilibrium reasoning can be used to describe the proton-transfer reactions of acid-base chemistry.
6.C.2: The pH is an important characteristic of aqueous solutions that can be controlled with buffers. Comparing pH to pKa allows one to determine the protonation state of a molecule with a labile proton.
6.C.3: The solubility of a substance can be understood in terms of chemical equilibrium.
6.D.1: When the difference in Gibbs free energy between reactants and products ($\Delta G°$) is much larger than the thermal energy (RT), the equilibrium constant is either very small (for $\Delta G° > 0$) or very large (for $\Delta G° < 0$). When $\Delta G°$ is comparable to the thermal energy (RT), the equilibrium constant is near 1.

# Appendix A: Biblical Principles for Science

## 1 God

- **a.** The Bible, as God's Word, and the findings of science do not conflict. (Psalm 19: 1-4; Romans 1:20)
- **b.** The fact that God is Creator is taught all through the Scriptures. (Genesis 1:1; Exodus 20:11)
- **c.** God has provided an orderly world. (Genesis 1)

## 2 Man

- **a.** Man is created in the image of God and has intrinsic honor, worth, and dignity. (Genesis 1:27-28)
- **b.** Man can never know all there is to know about the universe and about life. (Ecclesiastes 3:11; Romans 11:33-34)
- **c.** Men, by nature, are not neutral or objective observers of God's universe; man's ability to understand the truth is impaired by sin. (Romans 1:18-32; 1 Corinthians 2:14)

## 3 Creation

- **a.** God preserves His Creation so that it continues to function as He planned. (Colossians 1:17; 2 Peter 3:7)
- **b.** God controls every part of the natural world-His Creation-the world we study in science. (Job 9:5-7; Daniel 6:22, 24)
- **c.** All of Creation has been affected by man's sin. (Genesis 3:17-19; Romans 5:12)
- **d.** All of creation is meant to praise God and bring glory to Him. (Psalms 150:6; Romans 11:36)

## 4 Moral Order

- **a.** Science can be used for good or evil and should be used following the ethical mores of Scripture.
- **b.** Science should be used to demonstrate the existence of objective truths.
- **c.** Science can lead to solutions of world problems.

## 5 Purpose

- **a.** God desires that we study science - the details of His Creation - to know and glorify Him. (Genesis 1:28; Matthew 6:26-30)
- **b.** Science enables us to glorify God by doing the "good works" He has ordained for us more effectively.

# Appendix B:  Extended Physical Science Benchmarks

* Benchmark students have the opportunity to learn, but are not necessarily assessed over these benchmarks. Refer to Appendix B for details on benchmarks.

## 1 Motion and Forces

a. I can distinguish between, and solve problems involving, velocity, speed, and constant acceleration.
    i. I can create and interpret graphs of motion (position vs. time, speed vs. time, velocity vs. time, acceleration vs. time.)
b. I can apply Newton's Laws to solve motion problems.
    i. I can identify and describe the cause of forces that act on objects. i. e. friction, inertia, weight, mass, buoyancy, air resistance.
    ii. I know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).
    iii. I can apply the law F=ma to solve one-dimensional motion problems that involve constant forces (Newton's second law).
    iv. I know that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law).
c. I know the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth.
    i. I know applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed (e.g., Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed). I know circular motion requires the application of a constant force directed toward the center of the circle.
d. I know Newton's laws are not exact but provide very good approximations unless an object is moving close to the speed of light or is small enough that quantum effects are important.

## 2 Conservation of Energy and Momentum

a. I can solve problems involving conservation of energy in simple systems, such as falling objects.
    i. I can calculate kinetic energy by using the formula $E=(1/2)mv^2$ .
    ii. I can calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) =$mgh$ ($h$ is the change in the elevation).
    iii. I can calculate momentum as the product $mv$.
b. I can solve problems involving elastic and inelastic collisions in one dimension by using the principles of conservation of momentum and energy.
    i. I know momentum is a separately conserved quantity different from energy.
    ii. I know an unbalanced force on an object produces a change in its momentum.

## 3 Heat and Thermodynamics

a. I know heat flow and work are two forms of energy transfer between systems.
    i. I know that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy.
    ii. I know the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.
b. I know and can explain how heat flow affects phase changes.
c. I know that entropy is a quantity that measures the order or disorder of a system and that most processes tend towards disorder.
    i. I know the statement "Entropy tends to increase" is a law of statistical probability that governs all closed systems (second law of thermodynamics).

## 4 Waves

a. I know waves carry energy from one place to another without the transfer of matter.
b. I can identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
c. I can solve problems involving wavelength, frequency, and wave speed.
d. I know sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.
e. I can recognize the characteristics of a standing wave and explain how it forms.
f. I know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately $3\times10^8$ m/s (186,000 miles/second).
g. I can identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.
h. I know light color depends upon the wavelength of the electromagnetic wave.

## 5 Electric and Magnetic Phenomena

a. I can predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.
b. I can solve problems involving Ohm's law.
c. I know any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula Power = VI (potential difference) × I (current) = $I^2R = V^2/R$.
d. I know charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.

i - I know magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.
ii - I know changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.

## 6 Atomic and Molecular Structure

a. I can relate the position of an element in the periodic table to its atomic number and atomic mass. I can use the periodic table to identify metals, semimetals, nonmetals, and halogens. I can use the periodic table to determine the number of electrons available for bonding.
b. I can use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electronegativity, and the relative sizes of ions and atoms.

## 7 Chemical Bonds*

a. I know atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.
b. I know chemical bonds between atoms in molecules such as H2, CH4, NH3, H2C2H2, N2, Cl2, and many large biological molecules are covalent.
c. I know salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.
d. I know the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.

## 8 Gases and Their Properties*

a. I know the random motion of molecules and their collisions with a surface create the observable pressure on that surface. I know the random motion of molecules explains the diffusion of gases.
b. I can apply the gas laws to relations between the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.
c. I can convert between the Celsius and Kelvin temperature scales.
d. I know the kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms.

## 9 Investigation and Experimentation

a. I can use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

b. I can identify and communicate sources of unavoidable experimental error. I can identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
c. I can recognize the issues of statistical variability and the need for controlled tests.
d. I can formulate explanations by using logic and evidence.
e. I can distinguish between hypothesis and theory as scientific terms.
f. I can recognize the usefulness and limitations of models and theories as scientific representations of reality.

## 10 Connections*

a. I can analyze benefits, limitations, costs, and consequences involved in using technology or resources (for example, X-rays, agricultural chemicals, natural gas reserves).
b. I can analyze how the introduction of a new technology has affected or could affect human activity (for example, invention of the telescope, applications of modern telecommunications).
c. I can demonstrate the interrelationships between science and technology (for example, building a bridge, designing a better running shoe).
d. I can explain the use of technology in an occupation.
e. I can investigate careers based in the use of science and technology.
f. I can apply their knowledge and understanding of chemical and physical interactions to explain present and anticipated technologies (for example, lasers, ultrasound, superconducting materials, photocopy machines).
g. I can explore the scientific and technological aspects of contemporary problems (for example, issues related to nutrition, air quality, natural resources).
h. I know how to evaluate print and visual media for scientific evidence, bias, or opinion.
i. I can explain that the scientific way of knowing uses a critique and consensus process (for example, peer review, openness to criticism, logical arguments, skepticism).
j. I can use graphs, equations, or other models to analyze systems involving change and constancy (for example, comparing the geologic time scale to shorter time frames).
k. I can analyze and comparing models of cyclic change as used within and among scientific disciplines (for example, water cycle, circular motion, sound waves, and weather cycles).
l. I can identify and describing the dynamics of natural systems (for example, weather systems, ecological systems, body systems, systems at dynamic equilibrium).
m. I can analyze a model of a system involving change and constancy (for example, a mathematical expression for gas behavior; constructing a closed ecosystem such as an aquarium).