Integrated Faith Standards for Academic Curriculum

Science Curriculum

Grades 7 - 12

*Revised 2022

"Education is an important mission, which draws young people to what is good, beautiful, and true."

Pope Francis

Science is crucial for all students to master; not only those who seek careers in science, engineering, and medicine, but all citizens who live in the 21st century. These standards are created for students who live in a world where scientific understanding is not just an asset, but a necessity.

In studying science, we desire that our students in Catholic Schools will be able to:

- Demonstrate the mental practices of precise, determined, meticulous, and accurate questioning, inquiry, and reasoning of the Scientific Method.
- Learn that science involves exploration and particular procedures and ways of developing and organizing knowledge in an ongoing journey of discovery.
- Respond to the beauty, harmony, proportion, and wholeness existing in Nature.
- Appreciate how scientific hypothesis, investigation, and experimentation relate to other areas of study, especially the interplay of scientific research and theological and philosophical analysis.
- Articulate how scientific theories such as the Big Bang and evolution reflect the glory of the Creator.
- Communicate the significant contributions that the Catholic Church has made to the advancement of science, including the sponsorship of the first universities and such acclaimed scientists as Fr. Gregor Mendel, Fr. Georges Lemaître, Louis Pasteur, Nicholas Copernicus, Blaise Pascal, Galileo Galilei, Luigi Galvani, and Leonardo da Vinci.

The proposed Diocesan Curriculum Standards for Science adapted and reprinted from the *Indiana Academic Science Standards* will guide us in creating a science and engineering curriculum modeled on Design Process and the Scientific Method, enabling our students to approach the world with logic, reason, inquiry, and wonder. "Every scientist, through personal study and research, completes himself and his own humanity. ... Scientific research constitutes for you, as it does for many, the way for the personal encounter with truth, and perhaps the privileged place for the encounter itself with God, the Creator of heaven and earth. Science shines forth in all its value as a good capable of motivating our existence, as a great experience of freedom for truth, as a fundamental work of service. Through research each scientist grows as a human being and helps others to do likewise." – Pope Saint John Paul II.

Scientific Process Standards

The Nature of Scientific knowledge is scientists' best explanations for the data from many investigations. Ideas about objects in the microscopic world that we cannot directly sense are often understood in terms of concepts developed to understand objects in the macroscopic world that we can see and touch. Student work should align with this process of science and should be guided by those principles. Students should also understand that scientific knowledge is gained from observation of natural phenomena and experimentation by designing and conducting investigations guided by theory and by evaluating and communicating the results of those investigations according to accepted procedures. These concepts should be woven throughout daily work.

- Develop explanations to inquiries based on reproducible data and observations gathered during laboratory investigations.
- Recognize that their explanations must be based both on their data and other known information from investigations of others.

- Clearly communicate their ideas and results of investigations verbally and in written form using tables, graphs, diagrams and photographs.
- Regularly evaluate the work of their peers and in turn have their work evaluated by their peers.
- Apply standard techniques in laboratory investigations to measure physical quantities in appropriate units and convert quantities to other units as necessary.
- Use analogies and models (mathematical and physical) to simplify and represent systems that are difficult to understand or directly experience due to their size, time scale or complexity. Recognize the limitations of analogies and models.
- Focus on the development of explanatory models based on their observations during laboratory investigations.
- Explain that the body of scientific knowledge is organized into major theories, which are derived from and supported by the results of many experiments and allow us to make testable predictions.
- Recognize that new scientific discoveries often lead to a re-evaluation of previously accepted scientific knowledge and of commonly held ideas.
- Describe how scientific discoveries lead to the development of new technologies and conversely how technological advances can lead to scientific discoveries through new experimental methods and equipment.
- Explain how scientific knowledge can be used to guide decisions on environmental and social issues.

Basic Principles Underlying All Standards to be Used for the Planning of Curriculum for the Diocese of Manchester

- A passion for mission should inform every curriculum decision.
- All knowledge reflects God's Truth, Beauty, and Goodness.
- Curriculum and instruction enable deeper incorporation of the children into the Church, the formation of community within the school, and respect for the uniqueness and dignity of each person as created in the image and likeness of God.
- Education fosters growth in Christian virtue and contributes to development and formation of the whole person for the good of the society of which he/she is a member, and in recognition of their destiny, an eternal life in Christ.
- Each subject is to be examined in the context of the Catholic faith through Scripture and Tradition and is to be illuminated by Gospel values.
- Learning and formation are interconnected, as are the natural and spiritual development of each student.
- Curriculum and instruction seek to promote a synthesis of faith, life, and culture, forming students as disciples of Jesus.
- All curricula must support a commitment to strong and consistent Catholic identity.
- Curriculum will assist the student's ability to think critically, problem solve, innovate, and lead towards a supernatural vision.

In a Catholic School, Curricular Formation…

1. Involves the integral formation of the whole person, body, mind, and spirit, in light of his or her ultimate end and the good of society.[i]
2. Promotes human virtues and the dignity of the human person as created in the image and likeness of God and modeled on the person of Jesus Christ.[ii]
3. Seeks to know and understand objective reality, which includes transcendent Truth, is knowable by reason and faith, and finds its origin, unity, and end in God.
4. Develops a Catholic worldview and enables a deeper incorporation of the student into the heart of the Catholic Church.[iii]
5. Encourages a synthesis of faith, life, and culture.[iv]

Scientific Topics – General Standards

7-12.SCI.IF-GS.1.1 Exhibit care and concern at all stages of life for each human person as animage and likeness of God.

7-12.SCI.IF-GS.1.2 Describe the unity of faith and reason with confidence that there exists no contradiction between the God of nature and the God of faith.

7-12.SCI.IF-GS.1.3 Value the human body as the temple of the Holy Spirit.

7-12.SCI.IF-GS.1.4 Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences.

Scientific Topics – Intellectual Standards

7-12.SCI.IF-IS.2.1 Articulate how science properly situates itself within other academic disciplines (e.g., history, theology) for correction and completion in order to recognize the limited material explanation of reality to which it is properly attuned.

7-12.SCI.IF-IS.2.2 Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world.

7-12.SCI.IF-IS.2.3 Analyze how the pursuit of scientific knowledge, for utilitarian purposes alone or for the misguided manipulation of nature, thwarts the pursuit of authentic Truth and the greater glory of God.

7-12.SCI.IF-IS.2.4 Relate how the search for truth, even when it concerns a finite reality of the naturalworld or of man, is never-ending and always points beyond to something higher than the immediate object of study.

7-12.SCI.IF-IS.2.5 Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us.

7-12.SCI.IF-IS.2.6 Evaluate the relationship between God, man, and nature, and the proper role in the totality of being and creation.

7-12.SCI.IF-IS.2.7 Describe humanity's natural situation in, and dependence upon, physical reality and how man carries out his role as a cooperator with God in the work of creation.

7-12.SCI.IF-IS.2.8 Evaluate the errors present in the belief system of scientific naturalism or scientism[2] (which includes materialism[3] and reductionism[4]), which posits that scientific exploration and explanation is the only valid source of meaning.

7-12.SCI.IF-IS.2.9 Distinguish the difference between the use of the scientific method and the use of theological inquiry to know and understand God's creation and universal truths.

7-12.SCI.IF-IS.2.10 Articulate the limitations of science (the scientific method and constraints of the physical world) to know and understand God and transcendent reality.

7-12.SCI.IF-IS.2.11 Identify key Catholic scientists such as Copernicus, Mendel, DaVinci, Bacon, Pasteur, Volta, St. Albert the Great, and others and the witness and evidence they supply against the false claim that Catholicism is not compatible with science. List the basic contributions of significant Catholics to science such as Galileo, Copernicus, Mendel, and others.

7-12.SCI.IF-IS.2.12 Analyze and articulate the Church's approach to the theory of evolution.

7-12.SCI.IF-IS.2.13 Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents.

7-12.SCI.IF-IS.2.14 Explain how understanding the physiological properties of a human being does not address the existence of the transcendent spirit of the human person.

7-12.SCI.IF-IS.2.15 Explain the supernatural design hypothesis in terms of the Borde-Vilenkin-Guth Proof, the Second Law of Thermodynamics, entropy, and anthropic coincidences (fine tuning of initial conditions and universal constants).

7-12.SCI.IF-IS.2.16 Articulate the details of the Galileo affair to counter the assumption that the Church is anti-science.

7-12.SCI.IF-IS.2.17 Demonstrate an understanding of the moral issues involving in vitro fertilization, human cloning, human genetic manipulation, and human experimentation and what the Church teaches regarding work in these areas.

Scientific Topics – Dispositional Standards

7-12.SCI.IF-IS.3.1 Display a deep sense of wonder and delight about the natural universe.

7-12.SCI.IF-IS.3.2 Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator.

7-12.SCI.IF-IS.3.3 Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God.

7-12.SCI.IF-IS.3.4 Share concern and care for the environment as part of God's creation.

7-12.SCI.IF-IS.3.5 Adhere to the idea of the simultaneous complexity and simplicity of physical reality.

Literacy in Science/Technical Subjects: Read and Comprehend Science and Technical Texts Independently and Proficiently and Write Effectively for a Variety of Discipline-Specific Tasks, Purposes, and Audiences

9-10.SSO.LST-1.0	Read and comprehend science and technical texts within a range of complexity developmentally appropriate for grades 9-10 independently and proficiently by the end of grade 10.
9-10.SSO.LST-2.0	Write routinely over a variety of timeframes for a range of discipline-specific tasks, purposes, and audiences.

Key Ideas and Textual Support (Reading): Extract and Construct Meaning from Science and Technical Texts Using a Variety of Comprehension Skills

9-10.SSO.ITS-1.0	Demonstrate information literacy by citing specific textual evidence to support analysis of science and technical texts, and exercise academic integrity by attending to the precise details of explanations or descriptions, especially when citing source material.
9-10.SSO.ITS-2.0	Determine the central ideas or conclusions of a text; provide an accurate, objective summary of the text.
9-10.SSO.ITS-3.0	Properly follow a complex multistep procedure when carrying out experiments or taking measurements; analyze the specific results based on explanations in the text.

Structural Elements and Organization (Reading): Build Understanding of Science and Technical Texts Using Knowledge of Structural Organization and Author's Purpose and Message

9-10.SSO.SEO-1.0	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
9-10.SSO.SEO-2.0	Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.
9-10.SSO.SEO-3.0	Analyze previously researched material to determine the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

Synthesis and Connection of Ideas (Reading): Build Understanding of Science and Technical Texts by Synthesizing and Connecting Ideas and Evaluating Specific Claims

9-10.SSO.SCI-1.0	Integrate quantitative or technical information expressed in words from scientific literature and present the information visually (e.g., in a flowchart, diagram, model, graph, or table).
9-10.SSO.SCI-2.0	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
9-10.SSO.SCI-3.0	Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Writing Genres (Writing): Write for Different Purposes and to Specific Audiences or People

9-10.SSO.WG-1.0	Write arguments focused on discipline-specific content.
9-10.SSO.WG-1.1	Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
9-10.SSO.WG-1.2	Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
9-10.SSO.WG-1.3	Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
9-10.SSO.WG-1.4	Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which students are writing.
9-10.SSO.WG-1.5	Provide a concluding statement or section that follows from or supports the argument presented.
9-10.SSO.WG-2.0	Write informative texts, including scientific procedures/experiments or technical processes that include precise descriptions and conclusions drawn from data and research.
9-10.SSO.WG-2.1	Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aid comprehension.
9-10.SSO.WG-2.2	Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
9-10.SSO.WG-2.3	Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.

9-10.SSO.WG-2.4 Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.

9-10.SSO.WG-2.5 Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which students are writing.

9-10.SSO.WG-2.6 Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

9-10.SSO.WG-3.0 Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In science, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations that others can replicate them and (possibly) reach the same results.

The Writing Process (Writing): Produce Coherent and Legible Documents by Planning, Drafting, Revising, Editing, and Collaborating with Others

9-10.SSO.WP-1.0 Plan and develop; draft; revise using appropriate reference materials; rewrite; try a new approach; and edit to produce and strengthen writing that is clear and coherent, with some guidance and support from peers and adults.

9-10.SSO.WP-2.0 Use technology to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

The Research Process (Writing): Build Knowledge about the Research Process and the Topic under Study by Conducting Short or More Sustained Research

9-10.SSO.RP-1.0 Conduct short as well as more sustained research projects to answer a question (including a self-generated question), test a hypothesis, or solve a problem; narrow or broaden the inquiry when appropriate; and synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

9-10.SSO.RP-2.0 Demonstrate academic integrity and information literacy to gather relevant information from multiple authoritative sources, using advanced searches effectively; annotate sources; assess the usefulness of each source in answering the research question; and synthesize and integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation (e.g., *APA* or *CSE*).

9-10.SSO.RP-3.0 Draw evidence to form conclusions from informational texts to support analysis, reflection, and research.

Literacy in Science/Technical Subjects: Read and Comprehend Science and Technical Texts Independently and Proficiently and Write Effectively for a Variety of Discipline-Specific Tasks, Purposes, and Audiences

11-12.SSO.LST-1.0 Read and comprehend science and technical texts within a range of complexity developmentally appropriate for grades 11-12 independently and proficiently by the end of grade 12.

11-12.SSO.LST-2.0 Write routinely over a variety of timeframes for a range of discipline-specific tasks, purposes, and audiences.

Key Ideas and Textual Support (Reading): Extract and Construct Meaning from Science and Technical Texts Using a Variety of Comprehension Skills

11-12.SSO.ITS-1.0 Demonstrate information literacy by citing specific textual evidence to support analysis of science and technical texts, and exercise academic integrity by attending to the precise details of explanations or descriptions, especially when citing source material.

11-12.SSO.ITS-2.0 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

11-12.SSO.ITS-3.0 Properly follow a complex multistep procedure when carrying out experiments or taking measurements; analyze the specific results based on explanations in the text.

Structural Elements and Organization (Reading): Build Understanding of Science and Technical Texts Using Knowledge of Structural Organization and Author's Purpose and Message

11-12.SSO.SEO-1.0 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

11-12.SSO.SEO-2.0 Analyze how presented information or ideas can be structured into categories or hierarchies, demonstrating understanding of the information or ideas.

11-12.SSO.SEO-3.0 Analyze previously researched material to determine the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, and identifying important issues that remain unresolved.

Synthesis and Connection of Ideas (Reading): Build Understanding of Science and Technical Texts by Synthesizing and Connecting Ideas and Evaluating Specific Claims

11-12.SSO.SCI-1.0 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

11-12.SSO.SCI-2.0 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

11-12.SSO.SCI-3.0 Process and synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Writing Genres (Writing): Write for Different Purposes and to Specific Audiences or People

11-12.SSO.WG-1.0 Write arguments focused on discipline-specific content.

11-12.SSO.WG-1.1 Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

11-12.SSO.WG-1.2 Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.

11-12.SSO.WG-1.3 Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

11-12.SSO.WG-1.4 Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which students are writing.

11-12.SSO.WG-1.5 Provide a concluding statement or section that follows from or supports the argument presented.

11-12.SSO.WG-2.0 Write informative texts, including scientific procedures/experiments or technical processes that include precise descriptions and conclusions drawn from data and research.

11-12.SSO.WG-2.1 Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aid comprehension.

11-12.SSO.WG-2.2 Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

11-12.SSO.WG-2.3 Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.

11-12.SSO.WG-2.4 Use domain-specific vocabulary and techniques such as metaphor, simile, and analogy to express the complexity of the topic.

11-12.SSO.WG-2.5 Provide a conclusion that follows from and supports the information or explanation drawn from data and research.

11-12.SSO.WG-3.0 Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In science, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations that others can replicate them and (possibly) reach the same results.

The Writing Process (Writing): Produce Coherent and Legible Documents by Planning, Drafting, Revising, Editing, and Collaborating with Others

11-12.SSO.WP-1.0 Plan and develop; draft; revise using appropriate reference materials; rewrite; try a new approach; and edit to produce and strengthen writing that is clear and coherent, with some guidance and support from peers and adults.

11-12.SSO.WP-2.0 Use technology to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

The Research Process (Writing): Build Knowledge about the Research Process and the Topic under Study by Conducting Short or More Sustained Research

11-12.SSO.RP-1.0 Conduct short as well as more sustained research projects to answer a question (including a self-generated question), test a hypothesis, or solve a problem; narrow or broaden the inquiry when appropriate; and synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

11-12.SSO.RP-2.0 Demonstrate academic integrity and information literacy to gather relevant information from multiple authoritative sources, using advanced searches effectively; annotate sources; assess the usefulness of each source in answering the research question; and synthesize and integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation (e.g., *APA* or *CSE*).

11-12.SSO.RP-3.0 Draw evidence to form conclusions from informational texts to support analysis, reflection, and research.

For the high school science courses, the content standards are organized around the core ideas in each particular course. Within each core idea are indicators which serve as the more detailed expectations within each of the content areas.

Cellular Structure and Function

9-12.SC.CSF-1.0	Compare and contrast the structure and function of the essential biological macromolecules (i.e., carbohydrates, lipids, proteins, and nucleic acids), as well as how chemical elements (i.e., carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur) can combine to form these biomolecules.
9-12.SC.CSF-2.0	Understand how the characteristics of a molecule determine its role in the many different types of cellular processes (e.g., metabolism, homeostasis, growth and development, and heredity) and understand that the majority of these processes involve proteins that act as enzymes.
9-12.SC.CSF-3.0	Describe the structure of a cell membrane and explain how it regulates the transport of materials into and out of the cell and prevents harmful materials from entering the cell.
9-12.SC.CSF-4.0	Differentiate structures in prokaryotic and eukaryotic cells that are essential for growth and survival. Explain their functions.
9-12.SC.CSF-5.0	Develop and use models to illustrate how specialized structures within cells (i.e., nuclei, ribosomes, Golgi, endoplasmic reticulum) interact to produce, modify, and transport proteins.
9-12.SC.CSF-6.0	Understand that the cell is the basic unit of life, all living things are composed of one or more cells, and all cells come from preexisting cells.
9-12.SC.CSF-7.0	Develop and use a model to illustrate the hierarchical organization of interacting systems (macromolecules, organelles, cells, tissues, organs, organ systems) that provide specific functions within multicellular organisms.

Matter Cycles and Energy Transfer

9-12.SC.MCE-1.0	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy**.**
9-12.SC.MCE-2.0	Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.
9-12.SC.MCE-3.0	Describe how matter cycles and energy flows through an ecosystem by way of food chains and food webs and how organisms convert matter into a variety of organic molecules to be used in part in their own cellular structures.
9-12.SC.MCE-4.0	Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere**.**

Interdependence

9-12.SC.ITD-1.0 Explain that the amount of life environments can support is limited by the available energy, water, oxygen, and minerals and by the ability of ecosystems to recycle the remains of dead organisms; demonstrate this by comparing logistic and exponential graphs.

9-12.SC.ITD-2.0 Demonstrate and understand the use of scientific models to show how human activities and natural phenomena can change the flow of matter and energy in an ecosystem and how those changes impact the environment and biodiversity of populations in ecosystems of different scales, as well as how these human impacts can be reduced.

9-12.SC.ITD-3.0 Evaluate how complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, and identify the impact of changing conditions or introducing non-native species into that ecosystem.

Inheritance and Variation in Traits

9-12.SC.IVT-1.0 Develop a model that demonstrates the structure of DNA and how it can be used as a template for coding the traits passed from parents to offspring.

9-12.SC.IVT-2.0 Describe the process by which the DNA sequence directs the production of proteins, which carry out the essential functions of life through systems of specialized cells.

9-12.SC.IVT-3.0 Construct a model to explain that the unique structure and function of each protein is determined by the sequence of its amino acids, and thus is determined by the sequence of the DNA that codes for this protein.

9-12.SC.IVT-4.0 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

9-12.SC.IVT-5.0 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and (3) mutations caused by insertions, deletions, or substitutions.

9-12.SC.IVT-6.0 Explain that in multicellular organisms the zygote produced during fertilization undergoes a series of cell divisions that lead to clusters of cells that go on to specialize and become the organism's tissues and organs.

9-12.SC.IVT-7.0 Describe dominant, recessive, codominant, sex-linked, incompletely dominant, multiply allelic, and polygenic traits and illustrate their inheritance patterns over multiple generations.

9-12.SC.IVT-8.0 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

9-12.SC.IVT-9.0 Consider the ethical implications of genetic engineering (i.e., cloning, genetic modification, and selective breeding).

Evolution

9-12.SC.EVO-1.0	Evaluate anatomical and molecular evidence to provide an explanation of how organisms are classified and named based on their evolutionary relationships into taxonomic categories.
9-12.SC.EVO-2.0	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence, including both anatomical and molecular evidence.
9-12.SC.EVO-3.0	Describe how organisms with beneficial traits are more likely to survive, reproduce, and pass on their genetic information due to genetic variations, environmental forces, and reproductive pressure.
9-12.SC.EVO-4.0	Evaluate evidence to explain the role of natural selection as an evolutionary mechanism that leads to the adaptation of species, and to support claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and/or (3) the extinction of other species.
9-12.SC.EVO-5.0	Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
9-12.SC.EVO-6.0	Analyze and interpret data for patterns in the fossil record and molecular data that document the existence, diversity, extinction, and change of lifeforms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

Grade 9-12 Chemistry Content Standards

For the high school science courses, the content standards are organized around the core ideas in each particular course. Within each core idea are indicators which serve as the more detailed expectations within each of the content areas.

Properties and States of Matter

9-12.SC.PSM-1.0 Differentiate between pure substances and mixtures based on physical and chemical properties.

9-12.SC.PSM-2.0 Observe and describe chemical and physical properties of different types of matter and designate them as either extensive or intensive.

9-12.SC.PSM-3.0 Recognize observable macroscopic indicators of chemical changes.

9-12.SC.PSM-4.0 Describe physical and chemical changes at the particle level.

9-12.SC.PSM-5.0 Describe the characteristics of solids, liquids, and gases and changes in state at the macroscopic and microscopic levels.

9-12.SC.PSM-6.0 Demonstrate an understanding of the law of conservation of mass through the use of particle diagrams and mathematical models.

9-12.SC.PSM-7.0 Define density and distinguish among materials based on densities. Perform calculations involving density.

Atomic Structure and the Periodic Table

9-12.SC.APT-1.0 Using available experimental data, explain how and why models of atomic structure have changed over time.

9-12.SC.APT-2.0 Determine the number of protons, neutrons, and electrons in isotopes and calculate the average atomic mass from isotopic abundance data.

9-12.SC.APT-3.0 Write the full and noble gas electron configuration of an element, determine its valence electrons, and relate this to its position on the periodic table.

9-12.SC.APT-4.0 Use the periodic table as a model to predict the relative properties of elements based on the pattern of valence electrons and periodic trends.

9-12.SC.APT-5.0 Compare and contrast nuclear reactions with chemical reactions**.**

9-12.SC.APT-6.0 Describe nuclear changes in matter, including fission, fusion, transmutations, and decays.

9-12.SC.APT-7.0 Perform half-life calculations when given the appropriate information about the isotope.

Bonding and Molecular Structure

9-12.SC.BMS-1.0 Investigate the observable characteristics of elements, ionic, and covalent compounds.

9-12.SC.BMS-2.0 Compare and contrast how ionic and covalent compounds form.

9-12.SC.BMS-3.0 Draw structural formulas for simple molecules and determine their molecular shape.

9-12.SC.BMS-4.0 Write chemical formulas for ionic compounds and covalent compounds given their names and vice versa.

9-12.SC.BMS-5.0 Use laboratory observations and data to compare and contrast ionic, covalent, network, metallic, polar, and non-polar substances with respect to constituent particles, strength of bonds, melting, and boiling points and conductivity; provide examples of each type.

9-12.SC.BMS-6.0 Use structural formulas to illustrate carbon atoms' ability to bond covalently to one another to form many different substances.

Reactions and Stoichiometry

9-12.SC.RST-1.0 Describe, classify, and give examples of various kinds of reactions: synthesis (i.e., combination), decomposition, single displacement, double displacement, acid/base, and combustion.

9-12.SC.RST-2.0 Predict products of simple reactions as listed in previous standard.

9-12.SC.RST-3.0 Balance chemical equations and use the law of conservation of mass to explain why this must be true.

9-12.SC.RST-4.0 Apply the mole concept to determine the mass, moles, number of particles, or volume of a gas at STP, in any given sample, for an element or compound.

9-12.SC.RST-5.0 Use a balanced chemical equation to calculate the quantities of reactants needed and products made in a chemical reaction that goes to completion.

9-12.SC.RST-6.0 Perform calculations to determine the composition of a compound or mixture when given the necessary information.

9-12.SC.RST-7.0 Apply lab data to determine the empirical and molecular formula of a compound.

Behavior of Gases

9-12.SC.BGS-1.0 Use the kinetic molecular theory with the combined and ideal gas laws to explain changes in volume, pressure, moles, and temperature of a gas.

9-12.SC.BGS-2.0 Apply the ideal gas equation (PV = nRT) to calculate the change in one variable when another variable is changed and the others are held constant.

9-12.SC.BGS-3.0 Use lab data and a balanced chemical equation to calculate the volume of a gas at STP and non-STP conditions, assuming that the reaction goes to completion and the ideal gas law holds.

Thermochemistry

9-12.SC.THM-1.0 Explain that atoms and molecules are in constant motion and that this motion increases as thermal energy increases.

9-12.SC.THM-2.0 Distinguish between the concepts of temperature and heat flow in macroscopic and microscopic terms.

9-12.SC.THM-3.0 Classify chemical reactions and phase changes as exothermic or endothermic based on enthalpy values. Use a graphical representation to illustrate the energy changes involved.

9-12.SC.THM-4.0 Perform calculations involving heat flow, temperature changes, and phase changes by using known values of specific heat, phase change constants, or both.

Solutions

9-12.SC.SOL-1.0	Describe the composition and properties of solutions.
9-12.SC.SOL-2.0	Explain how temperature, pressure, and polarity of the solvent affect the solubility of a solute.
9-12.SC.SOL-3.0	Describe the concentration of solutes in a solution in terms of molarity. Perform calculations using molarity, mass, and volume. Prepare a sample of given molarity provided a known solute.
9-12.SC.SOL-4.0	Explain how the rate of a reaction is affected by changes in concentration, temperature, surface area, and the use of a catalyst.

Acids and Bases

9-12.SC.ACB-1.0	Classify solutions as acids or bases and describe their characteristic properties.
9-12.SC.ACB-2.0	Compare and contrast the strength of acids and bases in solutions.
9-12.SC.ACB-3.0	Given the hydronium ion and/or the hydroxide ion concentration, calculate the pH and/or the pOH of a solution. Explain the meanings of these values.

For the high school science courses, the content standards are organized around the core ideas in each particular course. Within each core idea are indicators which serve as the more detailed expectations within each of the content areas.

Constant Velocity

9-12.SC.CVL-1.0 Develop graphical, mathematical, and pictorial representations (e.g., a motion map) that describe the relationship between the clock reading (time) and position of an object moving at a uniform rate and apply those representations to qualitatively and quantitatively describe the motion of an object.

9-12.SC.CVL-2.0 Describe the slope of the graphical representation of position vs. clock reading (time) in terms of the velocity of the object.

9-12.SC.CVL-3.0 Rank the velocities of objects in a system based on the slope of a position vs. clock reading (time) graphical representation. Recognize that the magnitude of the slope representing a negative velocity can be greater than the magnitude of the slope representing a positive velocity.

9-12.SC.CVL-4.0 Describe the differences between the terms “distance and speed” as scalar quantities and “displacement and velocity” as vector quantities and be able to calculate any of those values given an object moving at a single constant speed/velocity or with different constant speeds/velocities over a given time interval.

Constant Acceleration

9-12.SC.CAC-1.0 Develop graphical, mathematical, and pictorial representations (e.g., a motion map) that describe the relationship between the clock reading (time) and velocity of an object moving at a uniformly changing rate and apply those representations to qualitatively and quantitatively describe the motion of an object.

9-12.SC.CAC-2.0 Describe the slope of the graphical representation of velocity vs. clock reading (time) in terms of the acceleration of the object.

9-12.SC.CAC-3.0 Rank the accelerations of objects in a system based on the slope of a velocity vs. clock reading (time) graphical representation. Recognize that the magnitude of the slope representing a negative acceleration can be greater than the magnitude of the slope representing a positive acceleration.

9-12.SC.CAC-4.0 Given a graphical representation of the position, velocity, or acceleration vs. clock reading (time), be able to identify or sketch the shape of the other two graphs.

9-12.SC.CAC-5.0 Qualitatively and quantitatively apply the models of constant velocity and constant acceleration to determine the position or velocity of an object moving in free fall near the surface of the Earth.

Forces

9-12.SC.FOR-1.0 Understand Newton's first law of motion and describe the motion of an object in the absence of a net external force according to Newton's first law.

9-12.SC.FOR-2.0 Develop graphical and mathematical representations that describe the relationship among the inertial mass of an object, the total force applied, and the acceleration of an object in one dimension (f=ma) where one or more forces is applied to the object and apply those representations to qualitatively and quantitatively describe how a net external force changes the motion of an object. Construct force diagrams using appropriately labeled vectors with magnitude, direction, and units to qualitatively and quantitatively analyze a scenario and make claims (i.e., develop arguments, justify assertions) about forces exerted on an object by another object.

9-12.SC.FOR-3.0 Understand Newton's third law of motion and describe the interaction of two objects using Newton's third law and the representation of action-reaction pairs of forces.

9-12.SC.FOR-4.0 Develop graphical and mathematical representations that describe the relationship between the gravitational mass of an object and the force due to gravity and apply those representations to qualitatively and quantitatively describe how changing the gravitational mass will affect the force due to gravity acting on the object.

9-12.SC.FOR-5.0 Describe the slope of the force due to gravity vs. gravitational mass graphical representation in terms of gravitational field.

9-12.SC.FOR-6.0 Explain that the equivalence of the inertial and gravitational masses leads to the observation that acceleration in free fall is independent of an object's mass.

Energy

9-12.SC.ENR-1.0 Describe and quantify (analytically) energy in its different mechanical forms (e.g., kinetic, gravitational potential, elastic potential) and recognize that these forms of energy can be transformed one into another and into non-mechanical forms of energy (e.g., thermal, chemical, nuclear, and electromagnetic).

9-12.SC.ENR-2.0 Conceptually define "work" as the process of transferring of energy into or out of a system when an object is moved under the application of an external force and operationally define "work" as the area under a force vs. change in position curve.

9-12.SC.ENR-3.0 For a force exerted in one or two dimensions, mathematically determine the amount of work done on a system by an unbalanced force over a change in position in one dimension, as well as define "power" as the amount of work done over a period of time.

9-12.SC.ENR-4.0 Understand and apply the principle of conservation of energy to determine the total mechanical energy stored in a closed system and mathematically show that the total mechanical energy of the system remains constant as long as no dissipative (i.e., non-conservative) forces are present.

9-12.SC.ENR-5.0 Develop and apply pictorial, mathematical, or graphical representations to qualitatively and quantitatively predict changes in the mechanical energy (e.g., translational kinetic, gravitational, or elastic potential) of a system due to changes in position or speed of objects or non-conservative interactions within the system.

9-12.SC.ENR-6.0 Review kinetic molecular theory (as needed) to reinforce Chemistry Standards.
-Describe temperature, thermal energy, and thermal energy transfer in terms of the kinetic molecular model. Expand the concept of conservation of mechanical energy to include thermal energy.
-Describe the kinetic molecular model, use it to derive the ideal gas law, and show how it explains the relationship between the temperature of an object and the average kinetic energy of its molecules.
- Use the kinetic theory to explain that the transfer of heat occurs during a change of state.
- Use examples from everyday life to describe the transfer of thermal energy by conduction, convection, and radiation.

Linear Momentum in One Direction

9-12.SC.LMD-1.0 For an object moving at constant rate, define linear momentum as the product of an object's mass and its velocity and be able to quantitatively determine the linear momentum of a single object.

9-12.SC.LMD-2.0 Operationally define "impulse" as the area under a force vs. change in clock reading (time) curve and be able to determine the change in linear momentum of a system acted on by an external force. Predict the change in linear momentum of an object from the average force exerted on the object and time interval during which the force is exerted.

9-12.SC.LMD-3.0 Demonstrate that when two objects interact through a collision or separation that both the force experienced by each object and change in linear momentum of each object are equal and opposite, and as the mass of an object increases, the change in velocity of that object decreases.

9-12.SC.LMD-4.0 Determine the individual and total linear momentum for a two-body system before and after an interaction (e.g., collision or separation) between the two objects and show that the total linear momentum of the system remains constant when no external force is applied consistent with Newton's third law.

9-12.SC.LMD-5.0 Classify an interaction (e.g., collision or separation) between two objects as elastic or inelastic based on the change in linear kinetic energy of the system.

9-12.SC.LMD-6.0 Mathematically determine the center of mass of a system consisting of two or more masses. Given a system with no external forces applied, show that the linear momentum of the center of mass remains constant during any interaction between the masses.

Simple Harmonic Oscillating Systems

9-12.SC.HOS-1.0 Develop graphical and mathematical representations that describe the relationship between the amount of stretch of a spring and the restoring force and apply those representations to qualitatively and quantitatively describe how changing the stretch or compression will affect the restoring force and vice versa, specifically for an ideal spring.

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9-12.SC.HOS-2.0 Describe the slope of the graphical representation of restoring force vs. change in length of an elastic material in terms of the elastic constant of the material, specifically for an ideal spring.

9-12.SC.HOS-3.0 Develop graphical and mathematical representations which describe the relationship between the mass, elastic constant, and period of a simple horizontal mass-spring system and apply those representations to qualitatively and quantitatively describe how changing the mass or elastic constant will affect the period of the system for an ideal spring.

9-12.SC.HOS-4.0 Develop graphical and mathematical representations which describe the relationship between the strength of gravity, length of string, and period of a simple mass-string (i.e., pendulum) system. Apply those representations to qualitatively and quantitatively describe how changing the length of string or strength of gravity will affect the period of the system in the limit of small amplitudes.

9-12.SC.HOS-5.0 Explain the limit in which the amplitude does not affect the period of a simple mass-spring (i.e., permanent deformation) or mass-string (i.e., pendulum, small angles) harmonic oscillating system.

Mechanical Waves and Sound

9-12.SC.MWS-1.0 Differentiate between transverse and longitudinal modes of oscillation for a mechanical wave traveling in one dimension.

9-12.SC.MWS-2.0 Understand that a mechanical wave requires a medium to transfer energy, unlike an electromagnetic wave, and that only the energy is transferred by the mechanical wave, not the mass of the medium.

9-12.SC.MWS-3.0 Develop graphical and mathematical representations that describe the relationship between the frequency of a mechanical wave and the wavelength of the wave and apply those representations to qualitatively and quantitatively describe how changing the frequency of a mechanical wave affects the wavelength and vice versa.

9-12.SC.MWS-4.0 Apply the mechanical wave model to sound waves and qualitatively and quantitatively determine how the relative motion of a source and observer affects the frequency of a wave as described by the Doppler Effect.

9-12.SC.MWS-5.0 Qualitatively and quantitatively apply the principle of superposition to describe the interaction (constructive or deconstructive) of two mechanical waves or pulses.

9-12.SC.MWS-6.0 Qualitatively describe the phenomena of both resonance frequencies and beat frequencies that arise from the interference of sound waves of slightly different frequency and define the beat frequency as the difference between the frequencies of two individual sound wave sources.

Particle and Wave Nature of Light

9-12.SC.MWS-1.0 Develop the relationship among frequency, wavelength, and energy for electromagnetic waves across the entire spectrum.

9-12.SC.MWS-2.0 Explain how electromagnetic waves interact with matter both as particles (i.e., photons) and as waves and be able to apply the most appropriate model to any particular scenario.

9-12.SC.MWS-3.0 Develop graphical and mathematical representations that describe the relationship between the frequency of a photon and the kinetic energy of an electron emitted through the photoelectric effect and apply those representations to qualitatively and quantitatively describe how changing the frequency or intensity of light affect the current produced in the photoelectric effect.

9-12.SC.MWS-4.0 Describe the slope of the graphical representation of the kinetic energy of a photoelectron vs. frequency in terms of Planck's constant.

9-12.SC.MWS-5.0 Develop graphical and mathematical representations that describe the relationship between the wavelength of monochromatic light, spacing between slits, distance to screen, and interference pattern produced for a double-slit scenario and apply those representations to qualitatively and quantitatively describe how changing any of the independent variables affects the position of the bright fringes.

9-12.SC.MWS-6.0 Develop graphical and mathematical representations that describe the relationship between the angle between two polarizing filters and the intensity of light passed through the filters from an unpolarized light source and apply those representations to qualitatively and quantitatively describe how changing the angle between polarizing filters affects the intensity of light passing through both filters.

Geometric Optics

9-12.SC.MWS-1.0 Develop graphical, mathematical, and pictorial representations (e.g., ray diagrams) that describe the relationships between the focal length, the image distance, and the object distance for planar, converging, and diverging mirrors and apply those representations to qualitatively and quantitatively describe how changing the object distance affects the image distance.

9-12.SC.MWS-2.0 Develop graphical, mathematical, and pictorial representations (e.g. ray diagrams) that describe the relationship between the angles of incidence and refraction of monochromatic light passed between two different media and apply those representations to qualitatively and quantitatively describe how changing the angle of incidence affects the angle of refraction.

9-12.SC.MWS-3.0 Develop graphical, mathematical, and pictorial representations (e.g., ray diagrams) that describe the relationships between the focal length, the image distance, and the object distance for both converging and diverging lenses and apply those representations to qualitatively and quantitatively describe how changing the object distance affects the image distance.

9-12.SC.MWS-4.0 Describe an image as real or virtual for both a curved mirror and lens system based on the position of the image relative to the optical device.

Electricity

9-12.SC.ELC-1.0	Describe the methods of charging an object (i.e., contact, induction, and polarization) and apply the principle of conservation of charge to determine the charges on each object after charge is transferred between two objects by contact.
9-12.SC.ELC-2.0	For a single isolated charge, develop and apply graphical and mathematical representations that describe the relationship between the amount of charge, the distance from the charge, and the strength of the electric field created by the charge (as a vector) and apply those representations to qualitatively and quantitatively describe how changing either the amount of charge or distance from the charge affects the strength of the electric field.
9-12.SC.ELC-3.0	Using Coulomb's law, pictorially and mathematically describe the force on a stationary charge due to other stationary charges. Understand that these forces are equal and opposite as described by Newton's third law and compare and contrast the strength of this force to the force due to gravity.
9-12.SC.ELC-4.0	For a single isolated charge, develop graphical and mathematical representations that describe the relationship between the amount of charge, the distance from the charge, and the electric potential created by the charge and apply those representations to qualitatively and quantitatively describe how changing either the amount of charge or distance from the charge affects the electric potential.
9-12.SC.ELC-5.0	Map electric fields and equipotential lines, showing the electric field lines are perpendicular to the equipotential lines, and draw conclusions about the motion of a charged particle either between or along equipotential lines due to the electric field.
9-12.SC.ELC-6.0	Distinguish between electric potential energy and electric potential (i.e., voltage).
9-12.SC.ELC-7.0	Apply conservation of energy to determine changes in the electric potential energy, translational kinetic energy, and speed of a single charged object (i.e., a point particle) placed in a uniform electric field.

Magnetism

9-12.SC.MAG-1.0	Describe the magnetic properties of ferromagnetic, paramagnetic, and diamagnetic materials on a macroscopic scale and atomic scale.
9-12.SC.MAG-2.0	Develop and apply a mathematical representation that describes the relationship between the magnetic field created by a long straight wire carrying an electric current, the magnitude of the current, and the distance to the wire.
9-12.SC.MAG-3.0	Describe the motion of a charged or uncharged particle through a uniform magnetic field.
9-12.SC.MAG-4.0	Determine the magnitude of the magnetic force acting on a charged particle moving through a uniform magnetic field and apply the right-hand rule to determine the direction of either the magnetic force or the magnetic field.
9-12.SC.MAG-5.0	Describe the practical uses of magnetism in motors, electronic devices, mass spectroscopy, MRIs, and other applications.

Electromagnetic Induction

9-12.SC.EMI-1.0 Given the magnitude and direction of a uniform magnetic field, calculate the flux through a specified area in terms of the field magnitude and the size and orientation of the area with respect to the field.

9-12.SC.EMI-2.0 Develop graphical and mathematical representations that describe the relationship between the rate of change of magnetic flux and the amount of voltage induced in a simple loop circuit according to Faraday's Law of Induction and apply those representations to qualitatively and quantitatively describe how changing the voltage across the device affects the current through the device.

9-12.SC.EMI-3.0 Apply Ohm's Law, Faraday's Law, and Lenz's Law to determine the amount and direction of current induced by a changing magnetic flux in a loop of wire or simple loop circuit.

Simple and Complex Circuits

9-12.SC.SCC-1.0 Relate the idea of electric potential energy to electric potential (i.e., voltage) in the context of electric circuits.

9-12.SC.SCC-2.0 Develop graphical and mathematical representations that describe the relationship between the amount of current passing through an ohmic device and the amount of voltage (i.e., EMF) applied across the device according to Ohm's Law. Apply those representations to qualitatively and quantitatively describe how changing the current affects the voltage and vice versa for an ohmic device of known resistance.

9-12.SC.SCC-3.0 Describe the slope of the graphical representation of current vs. voltage or voltage vs. current in terms of the resistance of the device.

9-12.SC.SCC-4.0 Define and describe a device as ohmic or non-ohmic based on the relationship between the current passing through the device and the voltage across the device based on the shape of the curve of a current vs. voltage or voltage vs. current graphical representation.

9-12.SC.SCC-5.0 Explain and analyze simple arrangements of electrical components in series and parallel DC circuits in terms of current, resistance, voltage, and power. Use Ohm's and Kirchhoff's laws to analyze DC circuits.

References:

Indiana Department of Education. (2010). *Indiana Academic Science Standards.* Retrieved from https://www.doe.in.gov/standards/science-computer-science

Indiana Department of Education. (2016). *Indiana Academic Science Standards.* Retrieved from https://www.doe.in.gov/standards/science-computer-science

Pope John Paul II. (2000). Address to the members of the Pontifical Academy of Sciences. In *L'Osservatore Romano*, translated in English edition, 5.

Pope Francis @ Pontifex. (3 June 2014). Retrieved from https://twitter.com/pontifex/status/473766101554196481?lang=en