# GRADE-LEVEL EXPECTATIONS (GLE) HANDBOOK

## SCIENCE
## GRADES 9–12


**LOUISIANA DEPARTMENT OF EDUCATION**

**CECIL J. PICARD**
**STATE SUPERINTENDENT OF EDUCATION**

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## LOUISIANA
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# GRADE-LEVEL EXPECTATIONS HANDBOOK OVERVIEW

## INTRODUCTION

In 1997, rigorous K–12 content standards were approved for mathematics, English language arts, science, social studies, foreign languages, and the arts. In conjunction with the development of these content standards, the Louisiana Department of Education (LDE) developed standards-based tests in English language arts, mathematics, science and social studies for grades 4, 8, 10, and 11. These tests have served as the basis for Louisiana's School and District Accountability System for several years. The development of Grade-Level Expectations (GLEs) in 2003 in English language arts, mathematics, science and social studies was a continuation of Louisiana's effort to expand and extend the content standards. GLEs identify what all students should know or be able to do by the end of a given grade level from prekindergarten through grade 12 in these four content areas.

## PURPOSES OF THE GLE HANDBOOKS

The Louisiana Grade-Level Expectations handbooks include grade-specific information about the GLEs. Each handbook includes introductory information for each content area contained within the handbook, a glossary, and tables that map the relationship between the standards and/or strands, benchmarks, and GLEs. Each handbook also correlates with one of fourteen GLE posters.

## GRADE-LEVEL EXPECTATIONS DEVELOPMENT GUIDELINES

Each grade-level expectation is meant to further define a content standard and benchmark(s). There is a progression of specificity; the standards represent broad statements, benchmarks are more specific, and GLEs provide the most detail. Grade-level expectations have been developed from prekindergarten through grade 12.

GLEs do not represent the entire curriculum for a given grade or course. Rather, they represent the core content that should be mastered by the end of a given year by all students. For mastery to be achieved at a given level, it may be necessary for those skills to be introduced at an earlier grade. Similarly, skills will need to be maintained after mastery has occurred.

The GLEs were developed with the following goals in mind:

- to articulate learning from PreK–12
- to be appropriate for the developmental or grade level of students
- to move from the concrete to the abstract
- to attend to prerequisite skills and understandings
- to be specific, but not so specific as to be too small in "grain size" compared with other GLEs for a particular content area

The GLEs were developed with an effort to avoid including:

- statements of curricular activities or instructional strategies
- value-laden concepts and understandings

## SUMMARY OF GLE DEVELOPMENT PROCESS

In December 2002, the LDE selected Data Recognition Corporation (DRC) as the contractor for the Grade-Level Expectations Project. The steps in the process of developing the Grade-Level Expectations for English language arts, mathematics, science, and social studies are described below.

1. **Identifying National Consultants.** National consultants representing each content area were selected to provide a national perspective to the GLE project and to assist the LDE and DRC with various steps in the GLE development process.

2. **Conducting Teacher Committee Meetings.** In March and April of 2003, content-area development committees, comprised of approximately 120 Louisiana classroom teachers, administrators, special populations teachers, and resource teachers chosen for their knowledge of standards and curriculum, were convened to assist with the development of the GLEs for English language arts, mathematics, science, and social studies.

3. **Completing Initial drafts.** The draft GLEs for the four content areas were completed and prepared for further review.

4. **Convening Focus Groups.** Two eighty-member groups of educators, nominated by their districts, reviewed the draft GLEs for horizontal and vertical alignments with the standards for English language arts, mathematics, science, and social studies and provided additional input on these initial drafts to the LDE.

5. **Conducting an Online/Electronic Public Review.** An online/electronic public review and feedback system was developed for the GLEs and made available on the LDE Web site. The purpose of this review was to solicit a broad range of feedback on the GLEs from parents, teachers, and other stakeholders.

6. **Completing an External Review.** With assistance from the staff of the Council of Chief State School Officers (CCSSO), twelve content specialists (three per content area) from other states or from universities or educational organizations across the nation were invited to serve on the review committee. In addition, the LDE also invited the national consultants from each content area to participate in the review meeting to answer questions about the development of the GLEs. External review committee members reviewed the GLE documents prior to the meetings, met with national consultants and LDE staff, and provided specific feedback on the GLEs via a written report.

7. **Conducting Final Committee Meeting.** The public comments and suggestions from the online public review were tabulated, and the additional comments and feedback from the external review committee meeting were compiled for sharing with committee members during the third and final GLE development committee meeting. The outcome of the third meeting of content-area committees consisted of suggestions for final edits that would be incorporated into the documents for presentation to the Louisiana State Board of Elementary and Secondary Education.

8. **Obtaining SBESE Board Approval of the GLEs.** In October 2003, the LDE staff presented the GLEs to the Louisiana State Board of Elementary and Secondary Education for review and approval.

9. **Conducting Preworkshops and GLE Awareness Workshops.** Two preworkshops for district supervisors in early December 2003 and fifteen GLE awareness workshops for local school personnel in late January 2004 have been conducted to inform educators about the grade-level expectations and their future role as it relates to curriculum and assessment

## CONCLUSION

Louisiana's content standards and benchmarks have guided the Louisiana education reform program for several years. As an extension of the content standards and benchmarks, the GLEs provide a link among instruction, curriculum, and assessment. The primary goal is a common understanding among parents, students, teachers, and the general public about what is expected of Louisiana students as they progress from grade to grade.

# SCIENCE INTRODUCTION

## GENERAL DEVELOPMENT PRINCIPLES

The content described by the Grade-Level Expectations (GLEs) does not represent the entire science curriculum for a grade or course. The GLEs indicate core content to be mastered by the end of a given grade. Science content can be added and enriched as appropriate for a district program, school, or student. For mastery to be attained, most content must be introduced earlier than the grade identified for mastery. Once a particular skill has been identified as a GLE, the skill should be reinforced in subsequent years, but it is not repeated in the list of expectations for subsequent years.

## ELEMENTARY: PREKINDERGARTEN–GRADE 4

Students at the prekindergarten (PreK) through grade 4 levels are learning to observe by using their senses, describing properties of substances using appropriate terminology, and comparing, sorting, classifying, and reading about the natural world. Science activities and investigations can be used to engage students in reading, expository writing, measuring, calculating, graphing, and communicating.

## MIDDLE SCHOOL: GRADES 5–8

To develop a deeper understanding of concepts, science content focus areas have been identified for grades 5–8. They are listed in Table 1.

**Table 1. Middle School Science Focus Areas**

| Grade | Focus Area |
|---|---|
| 5 | Integrated Science |
| 6 | Physical Science |
| 7 | Life Science |
| 8 | Earth and Space Science |

In addition to the designated focus areas, the Science as Inquiry (SI) and Science and the Environment (SE) strands are integrated into each of the middle school grades. Other content may be integrated locally within school districts. Additionally, districts not teaching middle school science in the same order as the focus areas may need to realign their curriculum to meet *i*LEAP assessment requirements.

## HIGH SCHOOL: GRADES 9–12

In high school, GLEs were developed for six science courses, one each at ninth- and tenth-grade levels and four for the eleventh- and twelfth-grade levels, with the following recommendations in mind (Table 2):

**Table 2. High School Courses**

| Strand | Course(s) | Recommended Grades |
|---|---|---|
| Physical Science | Physical Science | 9 |
| | Chemistry I | 11–12 |
| | Physics I | 11–12 |
| Life Science | Biology I | 10 |
| Earth and Space Science | Earth Science | 11–12 |
| Science and the Environment | Environmental Science | 11–12 |

Students may meet the state's high school graduation requirements in science in a variety of ways. Both personal preference and district course offerings affect which courses are taken and may determine the order in which courses are taken.

Chemistry and Physics are advanced Physical Science courses. GLEs for these courses are based on the Physical Science benchmarks but require higher-level skills and understandings. Prerequisite GLEs for Chemistry and Physics can be found in the Physical Science course recommended for grade nine.

## STANDARDS/BENCHMARKS/GLES

The organization of the science GLEs aligns with the *Louisiana Science Framework* (1997). The science GLEs address benchmarks from all five content strands outlined in the framework document.

Additional resources used to facilitate the development of the science GLEs include the *National Science Education Standards* (NSES, 1996), the National Assessment of Educational Progress *Science Framework* (NAEP, 1999), and the various Project 2061 publications of the American Association for the Advancement of Science. These national standards are reflected in the *Louisiana Science Framework* and the GLEs.

The five Louisiana science content standards are broad goals for what all students in Louisiana should know and be able to do in science. In the *Louisiana Science Framework*, strands are based on the five science standards. That is, each strand represents one of the five standards. The strands and their respective abbreviated codes are Science as Inquiry (SI), Physical Science (PS), Life Science (LS), Earth and Space Science (ESS), and Science and the Environment (SE). There is one process strand, Science as Inquiry, and four content strands. This organization into strands does not imply that science must be taught in separate isolated units. In fact, teachers are encouraged to teach integrated, interdisciplinary units of study.

Codes at the end of each GLE are used to identify a developmental profile indicator from the *Louisiana Standards for Programs Serving Four-Year-Old Children* (Table 3) and/or benchmarks from the *Louisiana Science Framework* (Table 4). A GLE may apply to more than one benchmark and, as a result, a GLE may have more than one code.

**Developmental Profile Indicator Code:** The first part of the code is always PK, which means prekindergarten. The second part, or term, indicates the domain and content area (i.e., Cognitive Science). The third term indicates the skill area, or strand, (i.e., PS, LS, ES) and skill number (e.g., 1, 2).

**Table 3. Explanation of Developmental Profile Indicator Codes**

| Code(s) | Explanation |
|---|---|
| PK-CS-L4 | Prekindergarten, Cognitive Science, Life Science, Skill 4 |
| PK-CS-P3 | Prekindergarten, Cognitive Science, Physical Science, Skill 3 |
| PK-CS-ES1 | Prekindergarten, Cognitive Science, Earth and Space Science, Skill 1 |

**Benchmark Codes:** The first term in the benchmark code refers to the strand (i.e., SI, PS, LS, ESS, SE). The second term refers to the grade cluster (i.e., E for elementary, M for middle school, and H for high school). The third term refers to the substrand and benchmark number (e.g., A1, B2, C3).

For most grade clusters, strands are divided into substrands or major topical areas. (The SE strand has no substrands at the PreK–4 and 5–8 grade levels.) Science GLEs have been developed and are organized based on this secondary breakdown. Substrands are indicated by the letters in the benchmark code designations.

**Table 4. Explanation of Benchmark Codes**

| Code(s) | Explanation |
|---|---|
| SI-E-A5 | SI strand, Elementary level, substrand A, benchmark 5 |
| PS-M-B4 | PS strand, Middle School level, substrand B, benchmark 4 |
| SE-H-A6<br>LS-H-D1 | SE strand, High School level, substrand A, benchmark 6 *and* LS strand, High School level, substrand D, benchmark 1 |

# SCIENCE INTRODUCTION

The SI standard states: *The students will **do** science by engaging in partial and full inquiries that are within their developmental capabilities*. The GLEs for the SI strand of the science framework are to be embedded in all science courses at every grade level and cannot be considered in isolation from the other strands. The processes and skills in the SI strand are to be integrated with the science content of the other four strands.

Each of the following GLE listings by grade opens with a summary describing the focal emphases of that grade. These emphases serve to shape and mold the program for that individual grade level. Careful articulation of these GLEs in a program will assure Louisiana a future marked by significant growth in students' abilities to learn, apply, and appreciate science concepts in all aspects of their lives.

# PHYSICAL SCIENCE INTRODUCTION

**Physical Science**

**Recommended for Ninth Grade**

This course and the associated Grade-Level Expectations include investigations into properties of matter, chemical reactions, forces and motion, and work and energy in the physical world. Students begin to examine and understand changes in materials by observing and measuring the results of simple chemical reactions and experiments involving mixing, heating, dissolving, and freezing. Students examine the periodic table to recognize patterns that explain why elements are grouped into families and periods. Physical Science provides a basis for the further study of physics, chemistry, and other related sciences.

## SAMPLE PAGE AND KEY FOR SCIENCE

Strand/ Standard

**Science As Inquiry: The students will do science by engaging in partial and full inquiries that are within their developmental capabilities.**

Substrand

***A. The Abilities Necessary to do Scientific Inquiry***

| Benchmarks | Grade-Level Expectations |
|---|---|
| **SI-E-A1:** asking appropriate questions about organisms and events in the environment | 1. Ask questions about objects and events in the environment (e.g., plants, rocks, storms) (SI-E-A1)<br>2. Pose questions that can be answered by using students' own observations, scientific knowledge, and testable scientific investigations (SI-E-A1) |
| **SI-E-A2:** planning and/or designing and conducting a scientific investigation | 3. Use observations to design and conduct simple investigations or experiments to answer testable questions (SI-E-A2)<br>4. Predict and anticipate possible outcomes (SI-E-A2)<br>5. Identify variables to ensure that only one experimental variable is tested at a time (SI-E-A2)<br>6. Use a variety of methods and materials and multiple trials to investigate ideas (observe, measure, accurately record data) (SI-E-A2) |
| **SI-E-A3:** communicating that observations are made with one's senses | 7. Use the five senses to describe observations (SI-E-A3) |
| **SI-E-A4:** employing equipment and tools to gather data and extend the sensory observations | 8. Measure and record length, temperature, mass, volume, and area in both metric system and U.S. system units (SI-E-A4)<br>9. Select and use developmentally appropriate equipment and tools (e.g., magnifying lenses, microscopes, graduated cylinders) and units of measurement to observe and collect data (SI-E-A4) |

Benchmarks

Grade-Level Expectations (GLEs)

# SCIENCE AS INQUIRY

# SCIENCE

**Science As Inquiry: The students will <u>do</u> science by engaging in partial and full inquiries that are within their developmental capabilities.**

***A. The Abilities Necessary to Do Scientific Inquiry***

| Benchmarks | Grade-Level Expectations |
|---|---|
| **SI-H-A1**: identifying questions and concepts that guide scientific investigations | 1. Write a testable question or hypothesis when given a topic (SI-H-A1) |
| **SI-H-A2**: designing and conducting scientific investigations | 2. Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)<br>3. Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls (SI-H-A2)<br>4. Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)<br>Also see GLE #9. |
| **SI-H-A3:** using technology and mathematics to improve investigations and communications | 5. Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)<br>6. Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3) |
| **SI-H-A4:** formulating and revising scientific explanations and models using logic and evidence | 7. Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4) |
| **SI-H-A5 :** recognizing and analyzing alternative explanations and models | 8. Give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected (SI-H-A5) |

| | |
|---|---|
| **SI-H-A6 :** communicating and defending a scientific argument | 9. Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2) |
| **S1-H-A7:** utilizing science safety procedures during scientific investigations | 10. Given a description of an experiment, identify appropriate safety measures (SI-H-A7) |
| ***B. Understanding Scientific Inquiry*** | |
| **SI-H-B1:** communicating that scientists usually base their investigations on existing models, explanations, and theories | 11. Evaluate selected theories based on supporting scientific evidence (SI-H-B1)<br>Also see GLE #16. |
| **SI-H-B2:** communicating that scientists conduct investigations for a variety of reasons, such as exploration of new areas, discovery of new aspects of the natural world, confirmation of prior investigations, evaluation of current theories, and comparison of models and theories | 12. Cite evidence that scientific investigations are conducted for many different reasons (SI-H-B2)<br>13. Identify scientific evidence that has caused modifications in previously accepted theories (SI-H-B2) |
| **SI-H-B3:** communicating that scientists rely on technology to enhance the gathering and manipulation of data | 14. Cite examples of scientific advances and emerging technologies and how they affect society (e.g., MRI, DNA in forensics) (SI-H-B3) |
| **SI-H-B4:** analyzing a proposed explanation of scientific evidence according to the following criteria: follow a logical structure, follow rules of evidence, allow for questions and modifications, and is based on historical and current scientific knowledge | 15. Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)<br>Also see GLE #16. |
| **SI-H-B5:** communicating that the results of scientific inquiry, new knowledge, and methods emerge from different types of investigations and public communication among scientists | 16. Use the following rules of evidence to examine experimental results:<br>• (a) Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability?<br>• (b) Has the technique or theory been subjected to peer review and publication?<br>• (c) What is the known or potential rate of error of the technique or theory when applied?<br>• (d) Were standards and controls applied and maintained?<br>• (e) Has the technique or theory been generally accepted in the scientific community? (SI-H-B5) (SI-H-B1) (SI-H-B4) |

# PHYSICAL SCIENCE

## SCIENCE

**Physical Science: Students will develop an understanding of the characteristics and interrelationships of matter and energy in the physical world.**

| *A. Measurement and Symbolic Representation* | |
|---|---|
| **Benchmarks** | **Grade-Level Expectations** |
| **PS-H-A1:** manipulating and analyzing quantitative data using the SI system | 1. Measure the physical properties of different forms of matter in metric system units (e.g., length, mass, volume, temperature) (PS-H-A1)<br>2. Gather and organize data in charts, tables, and graphs (PS-H-A1) |
| **PS-H-A2:** understanding the language of chemistry (formulas, equations, symbols) and its relationship to molecules, atoms, ions, and subatomic particles | 3. Distinguish among symbols for atoms, ions, molecules, and equations for chemical reactions (PS-H-A2)<br>4. Name and write chemical formulas using symbols and subscripts (PS-H-A2) |
| ***B. Atomic Structure*** | |
| **PS-H-B1:** describing the structure of the atom and identifying and characterizing the particles that compose it (including the structure and properties of isotopes) | 5. Identify the three subatomic particles of an atom by location, charge, and relative mass (PS-H-B1)<br>6. Determine the number of protons, neutrons, and electrons of elements by using the atomic number and atomic mass from the periodic table (PS-H-B1)<br>7. Describe the results of loss/gain of electrons on charges of atoms (PS-H-B1) (PS-H-C5) |
| **PS-H-B2:** describing the nature and importance of radioactive isotopes and nuclear reactions (fission, fusion, radioactive decay) | 8. Evaluate the uses and effects of radioactivity in people's daily lives (PS-H-B2)<br>9. Compare nuclear fission to nuclear fusion (PS-H-B2) |

| | |
|---|---|
| **PS-H-B3:** understanding that an atom's electron configuration, particularly that of the outermost electrons, determines the chemical properties of that atom | 10. Identify the number of valence electrons of the first 20 elements based on their positions in the periodic table (PS-H-B3)<br>Also see GLE #15. |
| ***C. The Structure and Properties of Matter*** | |
| **PS-H-C1:** distinguishing among elements, compounds, and/or mixtures | 11. Investigate and classify common materials as *elements*, *compounds*, or *mixtures* (heterogeneous or homogeneous) based on their physical and chemical properties (PS-H-C1)<br>Also see GLE #14. |
| **PS-H-C2:** discovering the patterns of physical and chemical properties found on the periodic table of the elements | 12. Classify elements as metals or nonmetals based on their positions in the periodic table (PS-H-C2) |
| **PS-H-C3:** understanding that physical properties of substances reflect the nature of interactions among its particles | 13. Predict how factors such as particle size and temperature influence the rate of dissolving (PS-H-C3)<br>Also see GLE #20. |
| **PS-H-C4:** separating mixtures based upon the physical properties of their components | 14. Investigate and compare methods for separating mixtures by using the physical properties of the components (PS-H-C4) (PS-H-C1) |
| **PS-H-C5:** understanding that chemical bonds are formed between atoms when the outermost electrons are transferred or shared to produce ionic and covalent compounds | 15. Using selected elements from atomic numbers 1 to 20, draw Bohr models (PS-H-C5) (PS-H-B3)<br>16. Name and write the formulas for simple ionic and covalent compounds (PS-H-C5)<br>17. Name and predict the bond type formed between selected elements based on their locations in the periodic table (PS-H-C5)<br>Also see GLE #7. |
| **PS-H-C6:** recognizing that carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures | 18. Diagram or construct models of simple hydrocarbons (four or fewer carbons) with single, double, or triple bonds (PS-H-C6) |

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| **PS-H-C7:** using the kinetic theory to describe the behavior of atoms and molecules during phase changes and to describe the behavior of matter in its different phases | 19. Analyze and interpret a graph that relates temperature and heat energy absorbed during phase changes of water (PS-H-C7)<br>20. Predict the particle motion as a substance changes phases (PS-H-C7) (PS-H-C3) |
| ***D. Chemical Reactions*** | |
| **PS-H-D1:** observing and describing changes in matter and citing evidence of chemical change | 21. Classify changes in matter as *physical* or *chemical* (PS-H-D1)<br>22. Identify evidence of chemical changes (PS-H-D1) |
| **PS-H-D2:** comparing, contrasting, and measuring the pH of acids and bases using a variety of indicators | 23. Classify unknowns as *acidic*, *basic*, or *neutral* using indicators (PS-H-D2) |
| **PS-H-D3:** writing balanced equations to represent a variety of chemical reactions (acid/base, oxidation/reduction, etc.) | 24. Identify balanced equations as neutralization, combination, and decomposition reactions (PS-H-D3)<br>Also see GLE #26. |
| **PS-H-D4:** analyzing the factors that affect the rate and equilibrium of a chemical reaction | 25. Determine the effect of various factors on reaction rate (e.g., temperature, surface area, concentration, agitation) (PS-H-D4) |
| **PS-H-D5:** applying the law of conservation of matter to chemical reactions | 26. Illustrate the laws of conservation of matter and energy through balancing simple chemical reactions (PS-H-D5) (PS-H-D3) (PS-H-D7) |
| **PS-H-D6:** comparing and contrasting the energy changes that accompany changes in matter | 27. Distinguish between endothermic and exothermic reactions (PS-H-D6) |
| **PS-H-D7:** identifying important chemical reactions that occur in living systems, the home, industry, and the environment | 28. Identify chemical reactions that commonly occur in the home and nature (PS-H-D7)<br>Also see GLE #26. |
| ***E. Forces and Motion*** | |
| **PS-H-E1:** recognizing the characteristics and relative strengths of the forces of nature (gravitational, electrical, magnetic, nuclear) | 29. Differentiate between *mass* and *weight* (PS-H-E1)<br>30. Compare the characteristics and strengths of forces in nature (e.g., gravitational, electrical, magnetic, nuclear) (PS-H-E1) |

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| **PS-H-E2:** understanding the relationship of displacement, time, rate of motion, and rate of change of motion; representing rate and changes of motion mathematically and graphically | 31. Differentiate between speed and velocity (PS-H-E2)<br>32. Plot and compare line graphs of acceleration and velocity (PS-H-E2)<br>33. Calculate velocity and acceleration using equations (PS-H-E2) |
| **PS-H-E3:** understanding effects of forces on changes in motion as explained by Newtonian mechanics | 34. Demonstrate Newton's three laws of motion (e.g., inertia, net force using F = ma, equal and opposite forces) (PS-H-E3) |
| **PS-H-E4:** illustrating how frame of reference affects our ability to judge motion | 35. Describe and demonstrate the motion of common objects in terms of the position of the observer (PS-H-E4) |
| ***F. Energy*** | |
| **PS-H-F1:** describing and representing relationships among energy, work, power, and efficiency | 36. Measure and calculate the relationships among energy, work, and power (PS-H-F1) |
| **PS-H-F2:** applying the universal law of conservation of matter, energy, and momentum, and recognizing their implications | 37. Model and explain how momentum is conserved during collisions (PS-H-F2)<br>38. Analyze diagrams to identify changes in kinetic and potential energy (PS-H-F2)<br>39. Distinguish among thermal, chemical, electromagnetic, mechanical, and nuclear energy (PS-H-F2)<br>40. Demonstrate energy transformation and conservation in everyday actions (PS-H-F2) |
| ***G. Interactions of Energy and Matter*** | |
| **PS-H-G1:** giving examples of the transport of energy through wave action | 41. Identify the parts and investigate the properties of transverse and compression waves (PS-H-G1)<br>42. Describe the relationship between wavelength and frequency (PS-H-G1)<br>43. Investigate and construct diagrams to illustrate the laws of reflection and refraction (PS-H-G1) |

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| **PS-H-G2:** analyzing the relationship and interaction of magnetic and electrical fields and the forces they produce | 44. Illustrate the production of static electricity (PS-H-G2)<br>45. Evaluate diagrams of series and parallel circuits to determine the flow of electricity (PS-H-G2)<br>46. Diagram a magnetic field (PS-H-G2)<br>47. Explain how electricity and magnetism are related (PS-H-G2) |
| **PS-H-G3:** characterizing and differentiating electromagnetic and mechanical waves and their effects on objects as well as humans | 48. Compare properties of waves in the electromagnetic spectrum (PS-H-G3)<br>49. Describe the Doppler effect on sound (PS-H-G3)<br>Also see GLE #50. |
| **PS-H-G4:** explaining the possible hazards of exposure to various forms and amounts of energy | 50. Identify positive and negative effects of electromagnetic/mechanical waves on humans and human activities (e.g., sound, ultraviolet rays, X-rays, MRIs, fiber optics) (PS-H-G4) (PS-H-G3) |

# BIOLOGY I INTRODUCTION

**Biology I**

**Recommended for Tenth Grade**

This course and the associated Grade-Level Expectations explore the characteristics, adaptations, body systems, and life cycles of organisms and their relationships with each other and their environment. Students examine the growth and development of organisms and study the levels of structural organization of living systems. Topics of concentration include cells, the molecular basis for heredity, structures and functions of human body systems, and contemporary health issues.

# BIOLOGY

# SCIENCE

**Life Science: The students will become aware of the characteristics and life cycles of organisms and understand their relationships to each other and to their environment.**

| *A. The Cell* | |
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| **Benchmarks** | **Grade-Level Expectations** |
| **LS-H-A1:** observing cells, identifying organelles, relating structure to function, and differentiating among cell types | 1. Compare prokaryotic and eukaryotic cells (LS-H-A1)<br>2. Identify and describe structural and functional differences among organelles (LS-H-A1)<br>3. Investigate and describe the role of enzymes in the function of a cell (LS-H-A1) |
| **LS-H-A2:** demonstrating a knowledge of cellular transport | 4. Compare active and passive cellular transport (LS-H-A2)<br>5. Analyze the movement of water across a cell membrane in hypotonic, isotonic, and hypertonic solutions (LS-H-A2) |
| **LS-H-A3:** investigating cell differentiation and describing stages of embryological development in representative organisms | 6. Analyze a diagram of a developing zygote to determine when cell differentiation occurs (LS-H-A3)<br>Also see GLE #15. |
| ***B. The Molecular Basis of Heredity*** | |
| **LS-H-B1:** explaining the relationship among chromosomes, DNA, genes, RNA, and proteins | 7. Identify the basic structure and function of nucleic acids (e.g., DNA, RNA) (LS-H-B1)<br>8. Describe the relationships among DNA, genes, chromosomes, and proteins (LS-H-B1)<br>Also see GLEs #12 and #13. |
| **LS-H-B2:** comparing and contrasting mitosis and meiosis | 9. Compare mitosis and meiosis (LS-H-B2) |

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| **LS-H-B3:** describing the transmission of traits from parent to offspring and the influence of environmental factors on gene expression | 10. Analyze pedigrees to identify patterns of inheritance for common genetic disorders (LS-H-B3)<br>11. Calculate the probability of genotypes and phenotypes of offspring given the parental genotypes (LS-H-B3) |
| **LS-H-B4:** exploring advances in biotechnology and identifying possible positive and negative effects | 12. Describe the processes used in modern biotechnology related to genetic engineering (LS-H-B4) (LS-H-B1)<br>13. Identify possible positive and negative effects of advances in biotechnology (LS-H-B4) (LS-H-B1) |
| ***C. Biological Evolution*** | |
| **LS-H-C1:** exploring experimental evidence that supports the theory of the origin of life | 14. Analyze evidence on biological evolution, utilizing descriptions of existing investigations, computer models, and fossil records (LS-H-C1)<br>15. Compare the embryological development of animals in different phyla (LS-H-C1) (LS-H-A3) |
| **LS-H-C2:** recognizing the evidence for evolution | 16. Explain how DNA evidence and fossil records support Darwin's theory of evolution (LS-H-C2) |
| **LS-H-C3:** discussing the patterns, mechanisms, and rate of evolution | 17. Explain how factors affect gene frequency in a population over time (LS-H-C3) |
| **LS-H-C4:** classifying organisms | 18. Classify organisms from different kingdoms at several taxonomic levels, using a dichotomous key (LS-H-C4) |
| **LS-H-C5:** distinguishing among the kingdoms | 19. Compare characteristics of the major kingdoms (LS-H-C5) |
| **LS-H-C6:** comparing and contrasting life cycles of organisms | 20. Analyze differences in life cycles of selected organisms in each of the kingdoms (LS-H-C6) |
| **LS-H-C7:** comparing viruses to cells | 21. Compare the structures, functions, and cycles of viruses to those of cells (LS-H-C7)<br>22. Describe the role of viruses in causing diseases and conditions (e.g., AIDS, common colds, smallpox, influenza, warts) (LS-H-C7) (LS-H-G2) |

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| ***D. Interdependence of Organisms*** | |
| **LS-H-D1:** illustrating the biogeochemical cycles and explaining their importance | 23. Illustrate the flow of carbon, nitrogen, and water through an ecosystem (LS-H-D1) (SE-H-A6)<br>Also see Environmental Science GLE #7. |
| **LS-H-D2:** describing trophic levels and energy flows | 24. Analyze food webs by predicting the impact of the loss or gain of an organism (LS-H-D2)<br>25. Evaluate the efficiency of the flow of energy and matter through a food chain/pyramid (LS-H-D2) |
| **LS-H-D3:** investigating population dynamics | 26. Analyze the dynamics of a population with and without limiting factors (LS-H-D3) |
| **LS-H-D4:** exploring how humans have impacted ecosystems and the need for societies to plan for the future | 27. Analyze positive and negative effects of human actions on ecosystems (LS-H-D4) (SE-H-A7) |
| ***E. Matter, Energy and Organization of Living Systems*** | |
| **LS-H-E1:** comparing and contrasting photosynthesis and cellular respiration; emphasizing their relationships | 28. Explain why ecosystems require a continuous input of energy from the Sun (LS-H-E1)<br>29. Use balanced equations to analyze the relationship between photosynthesis and cellular respiration (LS-H-E1) |
| **LS-H-E2:** recognizing the importance of the ATP cycle in energy usage within the cell | 30. Explain the role of adenosine triphosphate (ATP) in a cell (LS-H-E2) |
| **LS-H-E3:** differentiating among levels of biological organization | 31. Compare the levels of organization in the biosphere (LS-H-E3)<br>Also see GLE #32. |
| ***F. Systems and the Behavior of Organisms*** | |
| **LS-H-F1:** identifying the structure and functions of organ systems | 32. Analyze the interrelationships of organs in major systems (LS-H-F1) (LS-H-E3)<br>33. Compare structure to function of organs in a variety of organisms (LS-H-F1) |
| **LS-H-F2:** identifying mechanisms involved in homeostasis | 34. Explain how body systems maintain homeostasis (LS-H-F2) |

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| **LS-H-F3:** recognizing that behavior is the response of an organism to internal changes and/or external stimuli | 35. Explain how selected organisms respond to a variety of stimuli (LS-H-F3) |
| **LS-H-F4:** recognizing that behavior patterns have adaptive value | 36. Explain how behavior affects the survival of species (LS-H-F4) |
| ***G. Personal and Community Health*** | |
| **LS-H-G1:** relating fitness and health to longevity | 37. Explain how fitness and health maintenance can result in a longer human life span (LS-H-G1) |
| **LS-H-G2:** contrasting how organisms cause disease | 38. Discuss mechanisms of disease transmission and processes of infection (LS-H-G2) (LS-H-G4)<br>Also see GLE #22. |
| **LS-H-G3:** explaining the role of the immune system in fighting disease | 39. Compare the functions of the basic components of the human immune system (LS-H-G3)<br>40. Determine the relationship between vaccination and immunity (LS-H-G3) |
| **LS-H-G4:** exploring current research on the major diseases with regard to cause, symptoms, treatment, prevention, and cure | 41. Describe causes, symptoms, treatments, and preventions of major communicable and noncommunicable diseases (LS-H-G4)<br>Also see GLE #38. |
| **LS-H-G5:** researching technology used in prevention, diagnosis, and treatment of diseases/disorders | 42. Summarize the uses of selected technological developments related to the prevention, diagnosis, and treatment of diseases or disorders (LS-H-G5) |

# EARTH SCIENCE INTRODUCTION

**Earth Science**

**Recommended for Eleventh and Twelfth Grades**

This course and the associated Grade-Level Expectations integrate principles from the physical sciences, geography, and mathematics to focus on the dynamics, structures, properties, and interactions of the systems and subsystems of the Earth, the solar system, and the universe. Students explore the internal and external energy sources in the Earth system and constructive and destructive forces and processes of nature that alter the surface of the planet.

# EARTH SCIENCE

## SCIENCE

**Earth and Space Science: The students will develop an understanding of the properties of earth materials, the structure of the Earth system, the Earth's history, and the Earth's place in the universe.**

*A. Energy in Earth's System*

| Benchmarks | Grade-Level Expectations |
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| **ESS-H-A1:** investigating the methods of energy transfer and identifying the sun as the major source of energy for most of the Earth's systems | 1. Describe what happens to the solar energy received by Earth every day (ESS-H-A1)<br>2. Trace the flow of heat energy through the processes in the water cycle (ESS-H-A1)<br>3. Describe the effect of natural insulation on energy transfer in a closed system (ESS-H-A1) |
| **ESS-H-A2:** modeling the seasonal changes in the relative position and appearance of the sun and inferring the consequences with respect to the Earth's temperature | 4. Describe the relationship between seasonal changes in the angle of incoming solar radiation and its consequences to Earth's temperature (e.g., direct vs. slanted rays) (ESS-H-A2) |
| **ESS-H-A3:** explaining fission and fusion in relation to the Earth's internal and external heat sources | 5. Explain how the process of fusion inside the Sun provides the external heat source for Earth (ESS-H-A3)<br>Also see GLE #11. |
| **ESS-H-A4:** explaining how decay of radioactive isotopes and the gravitational energy from the Earth's original formation generates the Earth's internal heat | 6. Discuss how heat energy is generated at the inner core-outer core boundary (ESS-H-A4)<br>Also see GLE #11. |
| **ESS-H-A5:** demonstrating how the sun's radiant energy causes convection currents within the atmosphere and the oceans | 7. Analyze how radiant heat from the Sun is absorbed and transmitted by several different earth materials (ESS-H-A5)<br>8. Explain why weather only occurs in the tropospheric layer of Earth's atmosphere (ESS-H-A5) |

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| **ESS-H-A6:** describing the energy transfer from the sun to the Earth and its atmosphere as it relates to the development of weather and climate patterns | 9. Compare the structure, composition, and function of the layers of Earth's atmosphere (ESS-H-A6)<br>10. Analyze the mechanisms that drive weather and climate patterns and relate them to the three methods of heat transfer (ESS-H-A6) |
| **ESS-H-A7:** modeling the transfer of the Earth's internal heat by way of convection currents in the mantle which powers the movement of the lithospheric plates | 11. Describe the processes that drive lithospheric plate movements (i.e., radioactive decay, friction, convection) (ESS-H-A7) (ESS-H-A3) (ESS-H-A4)<br>12. Relate lithospheric plate movements to the occurrences of earthquakes, volcanoes, mid-ocean ridge systems, and off-shore trenches found on Earth (ESS-H-A7) |
| ***B. Geochemical Cycles*** | |
| **ESS-H-B1:** illustrating how stable chemical atoms or elements are recycled through the solid earth, oceans, atmosphere, and organisms | 13. Explain how stable elements and atoms are recycled during natural geologic processes (ESS-H-B1)<br>14. Compare the conditions of mineral formation with weathering resistance at Earth's surface (ESS-H-B1) |
| **ESS-H-B2:** demonstrating Earth's internal and external energy sources as forces in moving chemical atoms or elements | 15. Identify the sun-driven processes that move substances at or near Earth's surface (ESS-H-B2) |
| ***C. The Origin and Evolution of the Earth System*** | |
| **ESS-H-C1:** explaining the formation of the solar system from a nebular cloud of dust and gas | 16. Use the nebular hypothesis to explain the formation of a solar system (ESS-H-C1) |
| **ESS-H-C2:** estimating the age of the Earth by using dating techniques | 17. Determine the relative ages of rock layers in a geologic profile or cross section (ESS-H-C2)<br>18. Use data from radioactive dating techniques to estimate the age of earth materials (ESS-H-C2) |
| **ESS-H-C3:** communicating the geologic development of Louisiana | 19. Interpret geological maps of Louisiana to describe the state's geologic history (ESS-H-C3)<br>20. Determine the chronological order of the five most recent major lobes of the Mississippi River delta in Louisiana (ESS-H-C3) |

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| **ESS-H-C4:** examining fossil evidence as it relates to the evolution of life and the resulting changes in the amount of oxygen in the atmosphere | 21. Use fossil records to explain changes in the concentration of atmospheric oxygen over time (ESS-H-C4) |
| **ESS-H-C5:** explaining that natural processes and changes in the Earth system may take place in a matter of seconds or develop over billions of years | 22. Analyze data related to a variety of natural processes to determine the time frame of the changes involved (e.g., formation of sedimentary rock layers, deposition of ash layers, fossilization of plant or animal species) (ESS-H-C5) |
| ***D. The Origin and Evolution of the Universe*** | |
| **ESS-H-D1:** identifying scientific evidence that supports the latest theory of the age and origin of the universe | 23. Identify the evidence that supports the big bang theory (ESS-H-D1) |
| **ESS-H-D2:** describing the organization of the known universe | 24. Describe the organization of the known universe (ESS-H-D2) |
| **ESS-H-D3:** comparing and contrasting the sun with other stars | 25. Using the surface temperature and absolute magnitude data of a selected star, locate its placement on the Hertzsprung-Russell diagram and infer its color, size, and life stage (ESS-H-D3) |
| **ESS-H-D4:** identifying the elements found in the sun and other stars by investigating the spectra | 26. Identify the elements present in selected stars, given spectrograms of known elements and those of the selected stars (ESS-H-D4) |
| **ESS-H-D5:** describing the role of hydrogen in the formation of all the natural elements | 27. Trace the movement and behavior of hydrogen atoms during the process of fusion as it occurs in stars like the Sun (ESS-H-D5) |
| **ESS-H-D6:** demonstrating the laws of motion for orbiting bodies | 28. Identify the relationship between orbital velocity and orbital diameter (ESS-H-D6) (PS-H-E2)<br>29. Demonstrate the elliptical shape of Earth's orbit and describe how the point of orbital focus changes during the year (ESS-H-D6) |
| **ESS-H-D7:** describe the impact of technology on the study of the Earth, the solar system, and the universe | 30. Summarize how current technology has directly affected our knowledge of the universe (ESS-H-D7) |

# ENVIRONMENTAL SCIENCE INTRODUCTION

**Environmental Science**

**Recommended for Eleventh and Twelfth Grades**

This course and the associated Grade-Level Expectations provide an integration of scientific principles, ecological systems, resource management, environmental awareness, and environmental protection. Students study the biotic and abiotic factors in habitats, ecosystems, and biomes, plus the flow of energy through environmental systems. Environmental science has the goal of developing informed citizens by progressing through knowledge, understanding, appreciation, and stewardship of Earth's biosphere.

# ENVIRONMENTAL SCIENCE

## SCIENCE

**Science and the Environment: In learning environmental science, students will develop an appreciation of the natural environment, learn the importance of environmental quality, and acquire a sense of stewardship. As consumers and citizens, they will be able to recognize how our personal, professional, and political actions affect the natural world.**

### *A. Ecological Systems and Interactions*

| Benchmarks | Grade-Level Expectations |
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| **SE-H-A1:** demonstrating an understanding of the functions of Earth's major ecological systems | 1. Describe the abiotic and biotic factors that distinguish Earth's major ecological systems (SE-H-A1)<br>2. Describe the characteristics of major biomes on Earth (SE-H-A1) |
| **SE-H-A2:** investigating the flow of energy in ecological systems | 3. Use the 10% rule and data analysis to measure the flow of energy as represented by biomass in a system (SE-H-A2) |
| **SE-H-A3:** describing how habitat, carrying capacity, and limiting factors influence plant and animal populations (including humans) | 4. Determine the effects of limiting factors on a population and describe the concept of carrying capacity (SE-H-A3) |
| **SE-H-A4:** understanding that change is a fundamental characteristic of every ecosystem and that ecosystems have varying capacities for change and recovery | 5. Examine and discuss the major stages of succession, describing the generalized sequential order of the types of plant species (SE-H-A4) |
| **SE-H-A5:** describing the dynamic interactions between divisions of the biosphere | 6. Analyze the consequences of changes in selected divisions of the biosphere (e.g., ozone depletion, global warming, acid rain) (SE-H-A5) (SE-H-A7) |
| **SE-H-A6:** describing and explaining the Earth's biochemical and geochemical cycles and their relationship to ecosystem stability | 7. Illustrate the flow of carbon, water, oxygen, nitrogen, and phosphorus through an ecosystem (SE-H-A6) (LS-H-D1)<br>Also see Biology GLE #23. |

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| **SE-H-A7:** comparing and contrasting the dynamic interaction within the biosphere | 8. Explain how species in an ecosystem interact and link in a complex web (SE-H-A7) (SE-H-A10)<br>Also see GLE #6.<br>Also see Biology GLE #27. |
| **SE-H-A8:** analyzing evidence that plant and animal species have evolved physical, biochemical, and/or behavioral adaptations to their environments | 9. Cite and explain examples of organisms' adaptations to environmental pressures over time (SE-H-A8) |
| **SE-H-A9:** demonstrating an understanding of influencing factors of biodiversity | 10. Analyze the effect of an invasive species on the biodiversity within ecosystems (SE-H-A9)<br>11. Explain why biodiversity is essential to the survival of organisms (SE-H-A9) |
| **SE-H-A10:** explaining that all species represent a vital link in a complex web of interaction | See GLE #8. |
| **SE-H-A11:** understanding how pollutants can affect living systems | 12. Give examples and describe the effect of pollutants on selected populations (SE-H-A11) |
| ***B. Resources and Resource Management*** | |
| **SE-H-B1:** explaining the relationships between renewable and nonrenewable resources | 13. Evaluate whether a resource is renewable by analyzing its relative regeneration time (SE-H-B1) |
| **SE-H-B2:** comparing and contrasting conserving and preserving resources | 14. Analyze data to determine the effect of preservation practices compared to conservation practices for a sample species (SE-H-B2) |
| **SE-H-B3:** recognizing that population size and geographic and economic factors result in the inequitable distribution of the Earth's resources | 15. Identify the factors that cause the inequitable distribution of Earth's resources (e.g., politics, economics, climate) (SE-H-B3) |
| **SE-H-B4:** comparing and contrasting long and short-term consequences of resource management | 16. Evaluate the effectiveness of natural resource management in Louisiana (SE-H-B4) (SE-H-B5) |
| **SE-H-B5:** analyzing resource management | 17. Analyze data to determine when reuse, recycling, and recovery are applicable (SE-H-B5)<br>Also see GLE #16. |

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| **SE-H-B6:** recognizing that sustainable development is a process of change in which resource use, investment direction, technological development, and institutional change meet society's present as well as future needs | 18. Identify the factors that affect sustainable development (SE-H-B6) |
| ***C. Environmental Awareness and Protection*** | |
| **SE-H-C1:** evaluating the dynamic interaction of land, water, and air and its relationship to living things in maintaining a healthy environment | 19. Determine the interrelationships of clean water, land, and air to the success of organisms in a given population (SE-H-C1) |
| **SE-H-C2:** evaluating the relationships between quality of life and environmental quality | 20. Relate environmental quality to quality of life (SE-H-C2) |
| **SE-H-C3:** investigating and communicating how environmental policy is formed by the interaction of social, economic, technological, and political considerations | 21. Analyze the effect of common social, economic, technological, and political considerations on environmental policy (SE-H-C3) |
| **SE-H-C4:** demonstrating that environmental decisions include analyses that incorporate ecological, health, social, and economic factors | 22. Analyze the risk-benefit ratio for selected environmental situations (SE-H-C4) |
| **SE-H-C5:** analyzing how public support affects the creation and enforcement of environmental laws and regulations | 23. Describe the relationship between public support and the enforcement of environmental policies (SE-H-C5) |
| ***D. Personal Choices and Responsible Actions*** | |
| **SE-H-D1:** demonstrating the effects of personal choices and actions on the natural environment | 24. Identify the advantages and disadvantages of using disposable items versus reusable items (SE-H-D1) |
| **SE-H-D2:** analyzing how individuals are capable of reducing and reversing their impact on the environment through thinking, planning, education, collaboration, and action | 25. Discuss how education and collaboration can affect the prevention and control of a selected pollutant (SE-H-D2) (SE-H-D3) |
| **SE-H-D3:** demonstrating that the most important factor in prevention and control of pollution is education | See GLE #25. |
| **SE-H-D4:** demonstrating a knowledge that environmental issues should be a local and global concern | 26. Determine local actions that can affect the global environment (SE-H-D4) |

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| **SE-H-D5:** recognizing that the development of accountability toward the environment is essential for sustainability | 27. Describe how accountability toward the environment affects sustainability (SE-H-D5) |
| **SE-H-D6:** developing an awareness of personal responsibility as stewards of the local and global environment | 28. Discuss the reduction of combustible engines needed to significantly decrease $CO_2$ in the troposphere (SE-H-D6) |

# CHEMISTRY I INTRODUCTION

**Chemistry I**

**Recommended for Eleventh and Twelfth Grades**

This course and the associated Grade-Level Expectations focus on the properties and reactions of matter. Major topics include scientific measurement and problem solving, symbolic representation, properties and structure of matter, chemical reactions, and the relationship between matter and energy. Students perform laboratory investigations to explore the properties of substances and the behavior of gases. Students examine chemical interactions and learn about their applications in fields such as agriculture, manufacturing, and medicine.

# CHEMISTRY

## SCIENCE

**Physical Science: Students will develop an understanding of the characteristics and interrelationships of matter and energy in the physical world.**

| *A. Measurement and Symbolic Representation* | |
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| **Benchmarks** | **Grade-Level Expectations** |
| **PS-H-A1:** manipulating and analyzing quantitative data using the SI system | 1. Convert metric system units involving length, mass, volume, and time using dimensional analysis (i.e., factor-label method) (PS-H-A1)<br>2. Differentiate between accuracy and precision and evaluate percent error (PS-H-A1)<br>3. Determine the significant figures based on precision of measurement for stated quantities (PS-H-A1)<br>4. Use scientific notation to express large and small numbers (PS-H-A1) |
| **PS-H-A2:** understanding the language of chemistry (formulas, equations, symbols) and its relationship to molecules, atoms, ions, and subatomic particles | 5. Write and name formulas for ionic and covalent compounds (PS-H-A2)<br>6. Write and name the chemical formula for the products that form from the reaction of selected reactants (PS-H-A2)<br>7. Write a balanced symbolic equation from a word equation (PS-H-A2) |
| ***B. Atomic Structure*** | |
| **PS-H-B1:** describing the structure of the atom and identifying and characterizing the particles that compose it (including the structure and properties of isotopes) | 8. Analyze the development of the modern atomic theory from a historical perspective (PS-H-B1)<br>9. Draw accurate valence electron configurations and Lewis dot structures for selected molecules, ionic and covalent compounds, and chemical equations (PS-H-B1) |

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| **PS-H-B2:** describing the nature and importance of radioactive isotopes and nuclear reactions (fission, fusion, radioactive decay) | 10. Differentiate among *alpha*, *beta*, and *gamma* emissions (PS-H-B2)<br>11. Calculate the amount of radioactive substance remaining after a given number of half-lives has passed (PS-H-B2)<br>12. Describe the uses of radioactive isotopes and radiation in such areas as plant and animal research, health care, and food preservation (PS-H-B2) |
| **PS-H-B3:** understanding that an atom's electron configuration, particularly that of the outermost electrons, determines the chemical properties of that atom | 13. Identify the number of bonds an atom can form given the number of valence electrons (PS-H-B3) |
| ***C. The Structure and Properties of Matter*** | |
| **PS-H-C1:** distinguishing among elements, compounds, and/or mixtures | 14. Identify unknowns as elements, compounds, or mixtures based on physical properties (e.g., density, melting point, boiling point, solubility) (PS-H-C1) |
| **PS-H-C2:** discovering the patterns of physical and chemical properties found on the periodic table of the elements | 15. Predict the physical and chemical properties of an element based only on its location in the periodic table (PS-H-C2)<br>16. Predict the stable ion(s) an element is likely to form when it reacts with other specified elements (PS-H-C2)<br>17. Use the periodic table to compare electronegativities and ionization energies of elements to explain periodic properties, such as atomic size (PS-H-C2) |
| **PS-H-C3:** understanding that physical properties of substances reflect the nature of interactions among its particles | 18. Given the concentration of a solution, calculate the predicted change in its boiling and freezing points (PS-H-C3)<br>19. Predict the conductivity of a solution (PS-H-C3)<br>20. Express concentration in terms of molarity, molality, and normality (PS-H-C3) |
| **PS-H-C4:** separating mixtures based upon the physical properties of their components | 21. Design and conduct a laboratory investigation in which physical properties are used to separate the substances in a mixture (PS-H-C4) |

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| **PS-H-C5:** understanding that chemical bonds are formed between atoms when the outermost electrons are transferred or shared to produce ionic and covalent compounds | 22. Predict the kind of bond that will form between two elements based on electronic structure and electronegativity of the elements (e.g., ionic, polar, nonpolar) (PS-H-C5)<br>23. Model chemical bond formation by using Lewis dot diagrams for ionic, polar, and nonpolar compounds (PS-H-C5)<br>24. Describe the influence of intermolecular forces on the physical and chemical properties of covalent compounds (PS-H-C5) |
| **PS-H-C6:** recognizing that carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures | 25. Name selected structural formulas of organic compounds (PS-H-C6)<br>26. Differentiate common biological molecules, such as carbohydrates, lipids, proteins, and nucleic acids by using structural formulas (PS-H-C6)<br>27. Investigate and model hybridization in carbon compounds (PS-H-C6)<br>28. Name, classify, and diagram *alkanes*, *alkenes*, and *alkynes* (PS-H-C6) |
| **PS-H-C7:** using the kinetic theory to describe the behavior of atoms and molecules during phase changes and to describe the behavior of matter in its different phases | 29. Predict the properties of a gas based on gas laws (e.g., temperature, pressure, volume) (PS-H-C7)<br>30. Solve problems involving heat flow and temperature changes by using known values of specific heat and latent heat of phase change (PS-H-C7) |
| ***D. Chemical Reactions*** | |
| **PS-H-D1:** observing and describing changes in matter and citing evidence of chemical change | 31. Describe chemical changes and reactions using diagrams and descriptions of the reactants, products, and energy changes (PS-H-D1) |
| **PS-H-D2:** comparing, contrasting, and measuring the pH of acids and bases using a variety of indicators | 32. Determine the concentration of an unknown acid or base by using data from a titration with a standard solution and an indicator (PS-H-D2)<br>33. Calculate pH of acids, bases, and salt solutions based on the concentration of hydronium and hydroxide ions (PS-H-D2) |

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| **PS-H-D3:** writing balanced equations to represent a variety of chemical reactions (acid/base, oxidation/reduction, etc.) | 34. Describe chemical changes by developing word equations, balanced formula equations, and net ionic equations (PS-H-D3)<br>35. Predict products (with phase notations) of simple reactions, including acid/base, oxidation/reduction, and formation of precipitates (PS-H-D3)<br>36. Identify the substances gaining and losing electrons in simple oxidation-reduction reactions (PS-H-D3) |
| **PS-H-D4:** analyzing the factors that affect the rate and equilibrium of a chemical reaction | 37. Predict the direction of a shift in equilibrium in a system as a result of stress by using LeChatalier's principle (PS-H-D4) |
| **PS-H-D5:** applying the law of conservation of matter to chemical reactions | 38. Relate the law of conservation of matter to the rearrangement of atoms in a balanced chemical equation (PS-H-D5)<br>39. Conduct an investigation in which the masses of the reactants and products from a chemical reaction are calculated (PS-H-D5)<br>40. Compute percent composition, empirical formulas, and molecular formulas of selected compounds in chemical reactions (PS-H-D5)<br>41. Apply knowledge of stoichiometry to solve mass/mass, mass/volume, volume/volume, and mole/mole problems (PS-H-D5) |
| **PS-H-D6:** comparing and contrasting the energy changes that accompany changes in matter | 42. Differentiate between activation energy in endothermic reactions and exothermic reactions (PS-H-D6)<br>43. Graph and compute the energy changes that occur when a substance, such as water, goes from a solid to a liquid state, and then to a gaseous state (PS-H-D6)<br>44. Measure and graph energy changes during chemical reactions observed in the laboratory (PS-H-D6) |
| **PS-H-D7:** identifying important chemical reactions that occur in living systems, the home, industry, and the environment | 45. Give examples of common chemical reactions, including those found in biological systems (PS-H-D7) |

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| ***E. Forces and Motion*** | |
| **PS-H-E1:** recognizing the characteristics and relative strengths of the forces of nature (gravitational, electrical, magnetic, nuclear) | 46. Identify and compare intermolecular forces and their effects on physical and chemical properties (PS-H-E1) |
| **PS-H-E2:** understanding the relationship of displacement, time, rate of motion, and rate of change of motion; representing rate and changes of motion mathematically and graphically | Also see GLE #28. |
| **PS-H-E3:** understanding effects of forces on changes in motion as explained by Newtonian mechanics | |
| **PS-H-E4:** illustrating how frame of reference affects our ability to judge motion | |
| ***F. Energy*** | |
| ***There are no Grade-Level Expectations for Benchmarks in Grades 11 and 12 for this substrand.*** | |
| ***G. Interactions of Energy and Matter*** | |
| **PS-H-G1:** giving examples of the transport of energy through wave action | |
| **PS-H-G2:** analyzing the relationship and interaction of magnetic and electrical fields and the forces they produce | |
| **PS-H-G3:** characterizing and differentiating electromagnetic and mechanical waves and their effects on objects as well as humans | |
| **PS-H-G4:** explaining the possible hazards of exposure to various forms and amounts of energy | 47. Assess environmental issues related to the storage, containment, and disposal of wastes associated with energy production and use (PS-H-G4) |

# PHYSICS I INTRODUCTION

**Physics I**

**Recommended for Eleventh and Twelfth Grades**

The Physics course and the associated Grade-Level Expectations include in-depth investigations into the topics of force and motion, energy forms and transformations, interactions of energy and matter, and nuclear energy. Mathematical skills are integrated with scientific principles during problem-solving processes. Students investigate the characteristics and behavior of energy in the form of waves, light, electricity, and magnetism.

# PHYSICS

# SCIENCE

**Physical Science: Students will develop an understanding of the characteristics and interrelationships of matter and energy in the physical world.**

| *A. Measurement and Symbolic Representation* | |
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| **Benchmarks** | **Grade-Level Expectations** |
| **PS-H-A1:** manipulating and analyzing quantitative data using the SI system | 1. Measure and determine the physical quantities of an object or unknown sample using correct prefixes and metric system units (e.g., mass, charge, pressure, volume, temperature, density) (PS-H-A1)<br>2. Determine and record measurements correctly using significant digits and scientific notation (PS-H-A1)<br>3. Determine accuracy and precision of measured data (PS-H-A1)<br>4. Perform dimensional analysis to verify problem set-up (PS-H-A1)<br>5. Use trigonometric functions to make indirect measurements (PS-H-A1) |
| **PS-H-A2:** understanding the language of chemistry (formulas, equations, symbols) and its relationship to molecules, atoms, ions, and subatomic particles | |
| ***B. Atomic Structure*** | |
| ***There are no Grade-Level Expectations for Benchmarks in Grades 11 and 12 for this substrand.*** | |
| ***C. The Structure and Properties of Matter*** | |
| ***There are no Grade-Level Expectations for Benchmarks in Grades 11 and 12 for this substrand.*** | |

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| ***D. Chemical Reaction*** | |
| ***There are no Grade-Level Expectations for Benchmarks in Grades 11 and 12 for this substrand.*** | |
| ***E. Forces and Motion*** | |
| **PS-H-E1:** recognizing the characteristics and relative strengths of the forces of nature (gravitational, electrical, magnetic, nuclear) | 6. Explain the role of strong nuclear forces and why they are the strongest of all forces (PS-H-E1)<br>7. Relate gravitational force to mass and distance (PS-H-E1)<br>8. Compare and calculate electrostatic forces acting within and between atoms to the gravitational forces acting between atoms (PS-H-E1) |
| **PS-H-E2:** understanding the relationship of displacement, time, rate of motion, and rate of change of motion; representing rate and changes of motion mathematically and graphically | 9. Describe and measure motion in terms of position, displacement time, and the derived quantities of velocity and acceleration (PS-H-E2)<br>10. Determine constant velocity and uniform acceleration mathematically and graphically (PS-H-E2)<br>11. Plot and interpret displacement-time and velocity-time graphs and explain how these two types of graphs are interrelated (PS-H-E2)<br>12. Model scalar and vector quantities (PS-H-E2)<br>13. Solve for missing variables in kinematic equations relating to actual situations (PS-H-E2) |
| **PS-H-E3:** understanding effects of forces on changes in motion as explained by Newtonian mechanics | 14. Add and resolve vectors graphically and mathematically to determine resultant/equilibrant of concurrent force vectors (PS-H-E3)<br>15. Calculate centripetal force and acceleration in circular motion (PS-H-E3)<br>16. Analyze circular motion to solve problems relating to angular velocity, acceleration, momentum, and torque (PS-H-E3)<br>17. Analyze simple harmonic motion (PS-H-E3)<br>18. Demonstrate the independence of perpendicular components in projectile motion and predict the optimum angles and velocities of projectiles (PS-H-E3) |

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| **PS-H-E4:** illustrating how frame of reference affects our ability to judge motion | |
| ***F. Energy*** | |
| **PS-H-F1:** describing and representing relationships among energy, work, power, and efficiency | 19. Explain quantitatively the conversion between kinetic and potential energy for objects in motion (e.g., roller coaster, pendulum) (PS-H-F1)<br>20. Calculate the mechanical advantage and efficiency of simple machines and explain the loss of efficiency using the dynamics of the machines (PS-H-F1)<br>21. Explain and calculate the conversion of one form of energy to another (e.g., chemical to thermal, thermal to mechanical, magnetic to electrical) (PS-H-F1) |
| **PS-H-F2:** applying the universal law of conservation of matter, energy, and momentum, and recognizing their implications | 22. Analyze energy transformations using the law of conservation of energy (PS-H-F2)<br>23. Apply the law of conservation of momentum to collisions in one and two dimensions, including angular momentum (PS-H-F2)<br>24. Apply the concept of momentum to actual situations with different masses and velocities (PS-H-F2) |
| ***G. Interactions of Energy and Matter*** | |
| **PS-H-G1:** giving examples of the transport of energy through wave action | 25. Determine the relationships among amplitude, wavelength, frequency, period, and velocity in different media (PS-H-G1)<br>26. Evaluate how different media affect the properties of reflection, refraction, diffraction, polarization, and interference (PS-H-G1)<br>27. Investigate and construct diagrams to illustrate the laws of reflection and refraction (PS-H-G1)<br>28. Draw constructive and destructive interference patterns and explain how the principle of superposition applies to wave propagation (PS-H-G1) |

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| **PS-H-G2:** analyzing the relationship and interaction of magnetic and electrical fields and the forces they produce | 29. Describe observed electrostatic phenomena, calculate Coulomb's law, and test charge pole, electric field, and magnetic field (PS-H-G2)<br>30. Construct basic electric circuits and solve problems involving voltage, current, resistance, power, and energy (PS-H-G2)<br>31. Describe the relationship of electricity, magnetism, and inductance as aspects of a single electromagnetic force (PS-H-G2) |
| **PS-H-G3:** characterizing and differentiating electromagnetic and mechanical waves and their effects on objects as well as humans | 32. Compare properties of electromagnetic and mechanical waves (PS-H-G3)<br>33. Solve problems related to sound and light in different media (PS-H-G3)<br>34. Compare the properties of the electromagnetic spectrum as a wave and as a particle (PS-H-G3)<br>35. Analyze the Doppler effect of a moving wave source (PS-H-G3) |
| **PS-H-G4:** explaining the possible hazards of exposure to various forms and amounts of energy | |

# GLOSSARY

## SCIENCE GLOSSARY

**Acceleration** — The change in velocity per unit time; it is a vector quantity, as are velocity and position. The metric units of acceleration are meters per second squared or $m/s^2$.

**Aerobic Respiration** — Process of respiration that involves the release of energy from glucose or another organic compound in the presence of oxygen. The basic word equation that summarizes aerobic respiration is (glucose + oxygen $\rightarrow$ carbon dioxide + water + energy). The balanced chemical equation is $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O +$ energy. The energy produced is captured in adenosine triphosphate (ATP) molecules.

**Anaerobic Respiration** — Process of cellular respiration in which a cell obtains energy from inorganic molecules in the absence of oxygen.

**Biome** — A biome is a group of ecosystems that covers a large geographic area, related by having a similar type of vegetation, and governed by a similar climate. Examples of biomes are arctic tundra, coniferous forest, temperate forest, grassland, desert, tropical rain forest, and ocean.

**Biosphere** — Thin layer of Earth's surface where life exists; it includes all living organisms and all organic matter.

**Bohr Model** — Simplified, schematic model of the atom proposed by Niels Bohr in 1915 and more familiarly known as the planetary model. In the Bohr model, neutrons and protons occupy a dense central nucleus and the electrons orbit the nucleus.

**Cardinal Directions** — The four basic points (top or north, bottom or south, left side or west, and right side or east) on a compass.

**Carrying Capacity** — The maximum number of individuals of a species or population that an ecosystem can support without being degraded or destroyed over time.

**Celestial** — Of or related to the sky or universe, as the planets and stars.

**Centripetal Force** — Force acting on a body in curvilinear motion that pulls the object toward the center of curvature or axis of rotation.

# GLOSSARY

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| **Circuit** | Closed path followed by an electrical current. |
| **Closed System** | A complex unity of diverse parts that is isolated so that it experiences no interactions to the outside environment; a closed-loop system. |
| **Communicable Disease** | Disease that is transmittable between persons or species; contagious disease. |
| **Compression Waves** | Waves which travel back and forth in the same direction as the waves wave motion; an example of compression waves is sound waves; also known as longitudinal waves. |
| **Conductor** | Substance or medium that transmits heat, light, sound, or especially, an electrical charge. |
| **Consistency** | Repeatability or reproducibility of measurements. |
| **Continental Drift** | The movement of continents as described by the German geologist and meteorologist Alfred Wegener in 1915. A theory that proposed the continents had once been joined together and have slowly drifted apart by an unknown mechanism. Essentially this theory has been replaced by advances in plate tectonics, which built on the original theory of continental drift. |
| **Constants/Controls** | Those factors (variables) that are kept unchanged or are restricted during a controlled experiment. |
| **Control/Control Group** | A group of subjects or objects in a scientific experiment or group investigation that does not receive the treatment being tested. |
| **Controlled Experiment** | An experiment in which all but one of the variable factors are experiment kept the same in order to observe the results of changing one factor, the independent variable. |
| **Coulomb's Law** | Principle stating that electrostatic force is proportional to the product of the charges and inversely proportional to the square of the distance between them. Charles A. Coulomb, a French scientist, was the first to quantitatively measure the electrical attraction and repulsion between charged objects. |

# GLOSSARY

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| **Covalent Compound** | A compound in which bonded atoms share electrons; it is formed compound when two nonmetals bond to each other. |
| **Data** | Numerical or descriptive, factual information, especially that which is derived from scientific observations or experiments, organized for analysis. |
| **Dependent Variable** | A variable whose value is determined by the changes made in the variable independent variable. Those factors observed for changes in value as a result of adjustments made in the independent variable. |
| **Dichotomous Key** | Tool that can be used to correctly identify organisms or objects in the natural world (e.g., trees, flowers, rocks, minerals) through a series of divergent choices between two descriptions. |
| **Dimensional Analysis** | Problem-solving method based on the fact that any number or analysis mathematical expression can be multiplied by one without changing its value; also called factor-label method or unit factor method. |
| **Doppler Effect** | Apparent change in the wavelength of radiation caused by the relative motion of a source and the observer. As the source and/or the observer draw closer together, the observed frequency is higher than the emitted frequency and decrease as they move apart. |
| **Electromagnetic Waves** | Waves that involve varying electrical and magnetic fields at right angles to each other and the direction of wave propagation (direction of travel of the waves). Examples of these waves that together comprise the electromagnetic spectrum are light (visible, infrared, and ultraviolet) waves, microwaves, x-rays, gamma rays, and radio waves. |
| **Electrostatic Forces** | Forces between electrically-charged objects at rest, as measured and expressed by Coulomb's law. |
| **Empirical** | Based entirely on experimental evidence and observation rather than theory. |
| **Endothermic Chemical Reactions** | Chemical reactions such as photosynthesis that absorb energy in chemical order to proceed and cannot occur spontaneously; these types of reactions reactions are characterized by positive heat flow (i.e., into the reaction) and an increase in enthalpy. |

# GLOSSARY

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| **Eukaryotic Cells** | Cells that contain membrane-bound nuclei and organelles. |
| **Exothermic Chemical Reactions** | Chemical reactions that release energy in the form of heat, light, or chemical sound. In the laboratory, these reactions produce heat and may reactions be flammable or explosive. |
| **Genotype** | Combination of two alleles that an organism inherits for a certain trait; genetic makeup of an organism. |
| **Guiding Questions** | Questions that begin a process of thinking and questioning leading to discovery through exploration and manipulation of data. |
| **Habitat** | Specific environment or part of an ecosystem where an organism lives (e.g., woods, desert). |
| **Hertzsprung-Russell (HR) Diagram** | A two-dimensional plot of the observed stars used to group them by spectral class, relative luminosity (compared to Sun = 1), diagram absolute magnitude or degree of brightness on a logarithmic scale, and effective temperature (Kelvin). |
| **Homeostasis** | The maintenance of the internal environment in a system within tolerable limits; the resistance to change and the maintenance of equilibrium, or constant conditions, in a system. |
| **Hybridization** | 1. Cross-mating between two closely related species.<br><br>2. Concept dictating the nature of bonding and resulting molecular shapes of carbon compounds. |
| **Hypothesis** | Rational explanation of a single event or phenomenon based upon what has been observed but not proven. A tentative explanation for the cause of an observed phenomenon. |
| **Independent Variable** | Manipulated variable in a scientific experiment or investigation that determines the changes in the dependent variables. |
| **Inertia** | The tendency of a body at rest to remain at rest, or if moving in a straight line, to continue moving in a straight line, unless acted on by an outside force. |

# GLOSSARY

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| **Inexhaustible Resources** | Apparently endless resources such as the Sun, wind, or internal resources heat of Earth. |
| **Inference** | Process of drawing a conclusion or making a logical judgment based on prior conclusions or evidence but without direct observation. |
| **Inorganic Matter** | Matter not involving or relating to living organisms or the products of organic life. |
| **Inquiry** | Systematic process of using knowledge and skills to acquire and/or apply new knowledge and skills. |
| **Ion** | An atom or group of atoms that has acquired a net positive or negative electrical charge by gaining or losing one or more electrons. |
| **Ionic Compound** | A compound in which bonded atoms transfer electrons from one to the other; it is usually formed when metals bond to nonmetals. |
| **Kinetic Energy** | The energy of motion of an object, as expressed in the equation, $KE = ½ * m * v^2$, where m equals the mass of the object and v equals the speed of the object. |
| **Lewis Dot Structures** | Symbolic representations in atoms and simple ions showing structures valence electrons as dots placed around the symbol of the element, *and* structures illustrating covalent compounds or polyatomic ions showing valence electrons arranged among the atoms symbols in the molecule to illustrate the bonding of the atoms. |
| **Lithospheric Plate** | One of the movable sections of Earth's crust and upper mantle. |
| **Medium** | Substance, for example water or glass, through which something else, such as sound or light, is transmitted or carried. |
| **Metamorphosis** | Process of change of organisms through various stages in their life cycles. May be complete, involving the four stages of egg, larva, pupa, and adult, as in butterflies and moths, or incomplete, as in the gradual development of many insects and crustaceans. |

# GLOSSARY

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| **Metric System Units of Measurement** | Decimal system of weights and measurements that includes units of Standard International or SI units measurement. |
| **Meiosis** | Process of cellular division in which the number of chromosomes in each daughter cell is reduced by half the number in the parent cell. This cellular division process produces gametes. |
| **Mitosis** | Process of cellular division in which a cell's chromosomes are divided into two identical sets prior to cytoplasmic division. This process produces two identical daughter cells. |
| **Model** | Simulation of a real object that has explanatory power but that typically differs in size, scale, and/or detail; examples include plan, scheme, structure, or mathematical equation. |
| **Molality** | Number of moles of solute dissolved in one kilogram of solvent. |
| **Molarity** | Number of moles of solute dissolved in a liter of solution. |
| **Nebular Hypothesis** | Hypothesis for the origin of the solar system that proposes that hypothesis that the Sun and planets formed from the same cloud of gas and dust in interstellar space. |
| **Niche** | The role an organism carries out in its habitat. |
| **Noncommunicable Disease** | Disease that is not transmittable between persons or species; disease non-contagious disease. |
| **Nonpoint-source** | Sources of pollution that do not result from a single point or pollution source, for example, erosion of soil materials from multiple farms and construction sites that are carried and deposited in an adjacent stream as opposed to specific points of discharge. |
| **Nonstandard Tools** | Objects or instruments such as pieces of string, rows of blocks, tools fingers, hands, or pencils used for measurement; examples do not include standard and systematic means of measurement such as scales, rulers, clocks, and thermometers. |

# GLOSSARY

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| **Normality** | Concentration of a solution expressed in gram equivalent weights of solute per liter; it is particularly useful in titration calculations. |
| **Null Hypothesis** | Statistical hypothesis, often the reverse of what the experimenter actually believes, that is used to determine if the results obtained can be rejected merely on the basis of chance factors. |
| **Organic Matter** | Matter that is of, related to, or derived from living organisms. |
| **Phenotype** | The expression of an organism's traits as a result of its genetic makeup; outward appearance of an organism. |
| **Pitch** | Relative quality of highness or lowness of sound that is primarily dependent on the frequency of the waves produced by its source. |
| **Plate Tectonics** | Theory that Earth's outer shell consists of individual plates which interact in various ways and produce earthquakes, volcanoes, and mountain building. |
| **Point-source Pollution** | Pollution originating from a single source such as a discharge pipe from a sewage plant or chemical factory. |
| **Potable Water** | Water fit for human consumption. |
| **Potential Energy** | Energy that is stored in an object as a result of its vertical position. |
| **Precision** | The relative degree of exactness and reproducibility between measurements or estimates. |
| **Prokaryotic Cells** | Cells that lack an organized, membrane bound nucleus. |
| **Punnett Square** | Chart or grid system used to compute and visualize all possible genotypes of a genetic cross. |
| **Refract** | To deflect or bend from a straight path, as when a light wave changes direction as it passes from one medium into another of different density. |

# GLOSSARY

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| **Revolution** | The motion of a body or object around another body or object, for example, the revolution of Earth around the Sun. |
| **Rotation** | The spinning of a planet such as Earth or other object on its axis. |
| **Rules of Evidence** | Criteria used to examine and evaluate experimental results; examples include testability, reliability, application of standards and controls, error rate, subjection to peer review, and acceptance in the scientific community. |
| **Scalar Quantity** | A quantity that is completely specified by its magnitude and has no direction in space; examples are mass, length, volume, temperature, and speed. |
| **Scientific Evidence** | Evidence in which theories are validated against physical observations and not judged simply on the basis of their logical compatibility with available data; includes criteria such as testability, reliability, application of standards and controls, error rate, subjection to peer review, and acceptance in the scientific community. |
| **Sea-floor Spreading** | It is the process of producing new sea floor crust on the ocean floor between two diverging tectonic plates. |
| **Standard International (SI) Units of Measurement** | More complete, coherent version of the metric system of International measurement; basic units of the SI system include the centimeter (SI) units of or meter, gram or kilogram, and second. measurement |
| **Standard Tools** | Instruments such as meter sticks, pan balances, graduated cylinders, or thermometers used for systematic measurement. |
| **Statistical Significance** | A test performed to determine if the null hypothesis can be significance rejected, and if so, then the effect in the sample is found to be statistically significant. |
| **Stoichiometry** | Quantitative relationship between chemical substances in a reaction. |
| **Superposition** | Principle in geology which states that in any undisturbed sequence of sedimentary rocks each bed is older than the layers above and younger than the layers found below. |

# GLOSSARY

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| **Sustainability** | Capacity of continuing and maintaining a population and growth with minimal long-term effects on natural resources and the environment. *Sustainable* means that a process can be continued indefinitely without depleting the energy and resources upon which it depends. |
| **Sustainable Development** | Development that provides benefits now without sacrificing or development depleting resources or causing environmental impacts that will affect future generations. |
| **Symbolic Representation** | Ways in which science ideas such as chemical elements, formulas, representation ions, and equations are expressed; other examples include numbers in scientific notation illustrations, fractions, graphs, or spreadsheets. |
| **Terrestrial** | Relating to Earth or earthlike, its environments, or its inhabitants. |
| **Testable Question/ a Hypothesis/Investigation** | A query that can be answered through experimentation or research; hypothesis that makes predictions about the compatibility or investigation noncompatibility of observable evidence; an investigation or experiment to answer a testable question or hypothesis. |
| **Scientific Theory** | Explanation of a set of related observations or events based upon theory hypotheses that have verified through multiple investigations. Scientific theories differs from the general use of the word theory because this term applies to well tested and widely accepted ideas that explain certain observable facts. |
| **Translucent** | Transmitting light with sufficient diffusion so as to prevent distinct perception of images. |
| **Transverse Waves** | Waves in which the motion is up and down or at right angles to the direction of propagation or the direction in which the waves are traveling. Examples include radio waves, light waves, heat waves, and water waves. |
| **U.S. System Units of Measurement** | Principal and customary system of weights and measurements of measurement used in the U.S.A.; although the names of the units are the same as in the British system, the sizes of some units differ. |
| **Valence Electron** | Orbital electrons in the outermost shell of an atom that largely determine its properties and that are capable of forming chemical bonds with other atoms. |

# GLOSSARY

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| **Validity** | Degree to which an experimenter is measuring what s/he thinks; more generally refers to the strength of conclusions, inferences, propositions. |
| **Vector Quantity** | Quantity that is not complete unless both a magnitude and a direction are specified; an example is velocity. |
| **Velocity** | Vector quantity specifying both the speed and direction of a body or an object in motion. |
| **Zygote** | Fertilized egg resulting from the joining of two haploid gametes. |