This scope and sequence document was developed to assist teachers with the implementation of the Louisiana Student Standards for Science.

This document is considered a "living" document, as we believe that teachers and other educators will find ways to improve it as they use it. Please send feedback to STEM@la.gov so that we may use your input when updating this tool.

Updated July 26, 2021

About the Sample Scope and Sequence Tools

The Louisiana Student Standards for Science represent the knowledge and skills needed for students to successfully transition to postsecondary education and the workplace. The standards call for students to:

- Apply content knowledge
- Investigate, evaluate, and reason scientifically
- Connect ideas across disciplines

This scope and sequence document is designed to assist teachers, schools, and districts with instructional resources that were designed for three-dimensional standards like the Louisiana Student Standards for Science. This scope and sequence is only a sample; it does not illustrate the only appropriate sequence to teach the standards or the only possible ways to bundle the standards. The bundles can be reorganized around different phenomena, including phenomena specific to Louisiana or to a region in Louisiana.

Based on the instructional shifts, this tool provides sample units that use phenomena to drive 3-dimensional science instruction. The incorporated phenomena are observable events that occur in the universe and can be explained by science. They establish the purpose for learning and help students to connect their learning to real world events. The sample units include:

- storylines in which students use all three dimensions to make sense of phenomena or solve a problem presented in a design challenge;
- phenomena for each unit chosen based on student interest surveys; and
- embedded unit assessments including exit tickets, phenomena models, and three-dimensional tasks designed for students to apply learning to new phenomena.

inquiryHub Chemistry. inquiryHub: Research-based Curricula Supporting Next Generation Science. (2021, April 16). https://www.colorado.edu/program/inquiryhub/curricula/inquiryhub-chemistry.

Throughout each unit, students should have multiple opportunities to apply the science and engineering practices, make sense of the crosscutting concepts, and develop a deep understanding of disciplinary core ideas.

Building out the Science Scope and Sequence Sample Units for Classroom Instruction

How to Use the Anchor and Investigative Phenomena[1]

1. Explore the anchor phenomenon
2. Attempt to make sense of the phenomenon
3. Identify related phenomena
4. Develop questions and next steps
5. Explore investigative phenomena to help make sense of the anchor phenomenon
6. Communicate scientific reasoning around the anchor phenomenon

Instructional Process

Choosing an Anchor Phenomenon

Students should be able to make sense of anchoring phenomenon, but not immediately, and not without investigating it using sequences of the science and engineering practices. With instruction and guidance, students should be able to figure out, step by step, how and why the phenomenon works. [2]

A good anchor phenomenon[3]:

- ☐ is too complex for students to explain or design a solution for after a single lesson.
  - The explanation is just beyond the reach of what students can figure out without instruction.
  - Searching online will not yield a quick answer for students to copy.
- ☐ can be a case (pine beetle infestation, building a solution to a problem), something that is puzzling (why isn't rainwater salty?), or a wonderment (how did the solar system form?).
- ☐ has relevant data, images, and text to engage students in the range of ideas students need to understand. It should allow them to use a broad sequence of science and engineering practices to learn science through first-hand or second-hand investigations.

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[1] adapted from How do we bring 3-dimensional learning into our classroom?

[2] Using Phenomena

[3] Qualities of a Good Anchor Phenomenon

- □ will require students to develop an understanding of and apply multiple performance expectations while also engaging in related acts of mathematics, reading, writing, and communication.
- □ is observable to students. "Observable" can be with the aid of scientific procedures (e.g., in the lab) or technological devices to see things at very large and very small scales (telescopes, microscopes), video presentations, demonstrations, or surface patterns in data.

Choosing Investigative Phenomena

Students should be able to make sense of investigative phenomenon, but not immediately, and not without investigating it using sequences of the science and engineering practices. With instruction and guidance, students should be able to figure out, step-by-step, how and why the phenomenon works.[4]

A good investigative phenomenon:

- □ helps students make sense of one or two parts of the anchor phenomenon.
- □ has relevant data, images, and text to engage students in the range of ideas students need to understand.
- □ can be understood or explained by students using the science and engineering practices.

Investigating the Phenomena

When a phenomenon is introduced, whether anchor or investigative, students should have the opportunity to make observations, discuss current understandings, and pose questions about the phenomenon. Once questions are compiled, it may be helpful to categorize questions as follows:

- Questions that can be investigated by our class
- Questions that can be investigated but not with our current resources and equipment 🎬 Questions that can be researched
- Questions that cannot be answered (due to current technologies or scientific limitations)

Other Useful Questions When Designing a Sequence of Learning[5]

- How do we kick off investigations in a unit?
- How do we work with students to motivate the next step in an investigation?
- How do we help students use practices to figure out the pieces of the science ideas?
- How do we push students to go deeper and revise the science ideas we have built together so far?
- How do we help students put together pieces of the disciplinary core ideas and crosscutting concepts?

[4] Using Phenomena

[5] Questions to Guide the Development of a Classroom Culture That Supports "Figuring Out"

Chemistry Standards Overview

Chemistry focuses on the study of Matter and Its Interactions, Motion and Stability: Forces and Interactions, and Energy.

Crosscutting Concepts	Science and Engineering Practices								All Domains
	Asking Questions and Defining Problems	Developing and Using Models	Planning and Carrying Out Investigations	Analyzing and Interpreting Data	Using Mathematics and Computational Thinking	Constructing Explanations and Designing Solutions	Engaging in Argument from Evidence	Obtaining, Evaluating, and Communicating Information	
Patterns		HS-PS1-1	HS-PS1-3			HS-PS1-2 HS-PS1-5			
Cause and Effect									
Scale, Proportion, & Quantity									
Systems and System Models			HS-PS3-4		HS-PS3-1				
Energy & Matter		HS-PS1-4 HS-PS1-8			HS-PS1-7	HS-PS3-3		HS-PS3-6	
Structure & Function								HS-PS2-6	
Stability & Change						HS-PS1-6			

Overview of Sample Units

Full Course Landing Page, Sample Pacing Guide

	Unit 1 The Search for Life	Unit 2 Fuels	Unit 3 Oysters	Unit 4 Nuclear	Unit 5 Polar Ice
Unit Question	What substances should scientists look for when searching for life beyond Earth?	Why do cars run on gasoline and not rocket fuel?	Why are shellfish dying?	How could a single kilogram of nuclear material power an entire city but also destroy it? And should we use it (for either)?	Is there a way to stop or slow polar ice melting before the sea level rises too much?
Anchoring Phenomenon	We look at images of the night sky and wonder "Are there living things out there?"	We learn that carbon emissions are a huge problem, and that rocket fuel could mitigate carbon emissions; but we don't use it. Why?	We see a video of oyster farmers in the Northwest US and hear that the oysters are impacted by more acidic water. Why is that happening?	We wonder how an amount of nuclear material the size of a milk jug could ruin a city and if that power could be used for good.	We see how people are having to move away from coastal areas all around the world and we worry about where they can go.
Standards	**HS-PS1-1** **HS-PS1-2** **HS-PS1-3** **HS-PS2-6*** HS-ESS2-5* HS-ESS1-2*	**HS-PS1-4** HS-PS3-5 **HS-PS3-1** **HS-PS1-7** HS-ESS3-2	**HS-PS1-5** **HS-PS1-6** **HS-PS1-7** HS-ESS3-4 HS-ESS3-6	***HS-PS1-8*** HS-ESS3-2	**HS-PS3-1** **HS-PS3-4** HS-ESS2-2 HS-ESS3-4 HS-ESS3-5

** The performance expectation is only partially addressed using the identified phenomenon. HS-PS3-3 and HS-PS3-6 are not addressed by the inquiryHub Chemistry curriculum. The performance expectations can be incorporated by using the sample anchoring and investigative phenomena that follow as needed.*

Sample Unit: Nuclear Processes

This sample unit can be used to address standards that are not fully addressed by the sample scope and sequence on the previous page.

Performance Expectations

- HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level and the composition of the nucleus of atoms.
- HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
- ***HS-PS3-6: Evaluate the validity and reliability of claims in published materials about the viability of nuclear power as a source of alternative energy relative to other forms of energy (e.g., fossil fuels, wind, solar, geothermal).***

Disciplinary Core Ideas

DCI	Partial Unpacking of the DCI
Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (DCI: HS.PS1A.a; PE: HS-PS1-1)	• An atom is made of subatomic particles: protons, neutrons and electrons. • The nucleus of an atom contains protons (positively charged) and neutrons, which have no net electric charge. • A positively charged nucleus is surrounded by much smaller negatively charged electrons. • Electrons are configured around the nucleus in energy levels. • Electrons in the outmost energy level are called valence electrons. • Atoms with unstable nuclei, called radionuclides, are characterized by excess energy and experience radioactive decay. This is due to the ration of protons to neutrons. • The energy within an energy level increases as its distance from the nucleus increases (e.g. an electron in the sixth energy level has more energy than an electron in the second energy level.

The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (DCI: HS.PS1A.b; PE: HS-PS1-1)	The Periodic Table of Elements is an arrangement of the chemical elements ordered by atomic number or the number of protons in atoms. The arrangement of the main groups of the periodic table reflects the patterns of electrons in the outermost energy level of atoms, and therefore, the chemical properties of the elements in each group. The atomic mass listed for each element on the periodic table corresponds to the relative abundance of that element's different isotopes.
Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (DCI: HS.PS2B.c; PE: HS-PS1-1)	The periodic table is used to predict the patterns of behavior of the elements. The patterns and behaviors of elements are based on the attraction and repulsion between electrically charged particles and the patterns of the outermost electrons. The relative reactivity and electronegativity of atoms can be determined by an element's location on the periodic table and its valence electrons attraction to the nucleus. The number and types of bonds formed by an element and between elements, the number and charges of stable ions, and the relative sizes of atoms can be determined by an elements location on the periodic table.
Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (DCI: HS.PS1C.a; PE: HS-PS1-8 and HSPS3-6)	Fission, fusion and radioactive decay (alpha, beta and gamma) are nuclear processes. Nuclear fission and fusion reactions release energy as the nuclear force, which binds protons and neutrons, and electrostatic forces, which cause protons to repel, are disrupted. These reactions require initial energy input in order to occur. In fission reactions, an atom is split into two or more smaller atoms. When the nucleus splits into two or more fragments each have a smaller number of protons than were in the original nucleus.

	- In fusion reactions, two smaller atoms fuse together to create a heavier atom. When the two nuclei merge to form a single larger nucleus, more protons are present than were in either of the two original nuclei. - When a nuclear process takes place, radioactive particles may be produced. - Radioactive particles or decay occur when an unstable atomic nucleus loses energy by emitting radiation. - Radioactive isotopes decay, or emit radiation, at constant and characteristic rates called half-lives. - There are differences in the type of energy (kinetic energy and electromagnetic radiation) and type of particle (alpha and beta) released during alpha, beta, and gamma radioactive decay, and any change from one element to another can occur due to the process. - The total number of nuclear particles are the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after. - The scale of energy released or absorbed in a nuclear process is much larger (hundreds of thousands or even millions of times larger) than the scale of energy released or absorbed in a chemical process. - The energy that is released or absorbed during nuclear processes are harmful to human tissues.
When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (DCI: (HS.ETS1B.a); PE: HS-PS3-6)	- When scientists and engineers create solutions to problems, they use specific criteria to guide the development of their solutions. - When scientists and engineers create solutions to problems, they consider the constraints of their design solutions including cost, safety, aesthetics, and reliability. - The energy that is released or absorbed during nuclear processes are harmful to human tissues and can cause various forms of cancer.

All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (DCI: HS.ESS3A.b; PE: HS-PS3-6)	Nuclear energy production has economic, social, environmental, and geopolitical costs, risks and benefits. The United States government regulates nuclear energy production. Safety and environmental regulations are in place.

Science and Engineering Practices

- Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
- Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Crosscutting Concepts

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Putting the Standards into Practice

Sample Anchor Phenomenon:
Japanese people living in the area where Fukushima Daiichi nuclear disaster took place have a higher risk of developing cancer.

Explore the anchor phenomenon

Fukushima Nuclear Plant Explosion
Nuclear Plant Explosion
Fukushima Nuclear Disaster
ABC: Fukushima Nuclear Disaster Anniversary
CNN: Fukushima Disaster Zone

Resources: A number of resources for the anchor phenomenon are included below. Teachers should screen the resources and pull photos, quotes, and data that are appropriate to share with high school students. These resources are not appropriate to be given to students as they are due to length, content, or accessibility of the content.

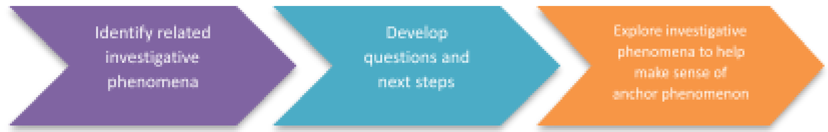
Questions students may pose that could be used for future learning or investigations:

Try to make sense of the anchor phenomenon

- What caused the nuclear disaster in Fukushima?
- What was the environmental and economic impact of the disaster?
- Did people return to the area after the disaster?
- How long does radiation remain in the air after a nuclear disaster?
- What impact does radiation have on living organisms?
- How are scientists and health organizations monitoring the long term health of the Japanese people?
- Is nuclear energy used in the United States? How does the government regulate nuclear energy?
- What is nuclear energy and how is it produced? 🎬 Is nuclear energy used in Louisiana?

Teachers should provide Investigative Phenomenon based on student observations, questions, and the Characteristics of Quality Investigative Phenomenon.

Sample Investigative Phenomena



Sample 1: Uranium and polonium have different properties.

Sample questions for students to investigate: 3-D learning opportunities:

- What subatomic particles make up atoms, such as uranium and polonium?
- What unique properties do the subatomic particles of an atom possess? Develop and use an atomic model to support your response.
- Develop and use a model of the Periodic Table of Elements to support your response to the following questions:
- How are chemical elements organized on the Periodic Table of Elements?
- What patterns are used to organize the Periodic Table of Elements? How are these patterns used to determine the reactivity and properties of elements?
- Where is uranium and polonium located on the Periodic Table of Elements? What do the location of the elements tell you about their reactivity and electronegativity and the relative sizes of their atoms?
- How are valence electrons used to determine the reactivity and electronegativity of an element?
- How are the properties of uranium and polonium different from other elements on the Periodic Table of Elements?
- Based on your analysis of uranium on the Periodic Table of Elements, why is it used to power nuclear processes?
- How often is the Periodic Table of Elements updated? How do scientists determine if new elements should be added to the table?

SEP: Develop and use a model; Construct an explanation

DCI: HS.PS1A.a; HS.PS1A.b; HS.PS2B.c

CCC: Patterns

Sample 2: A breast cancer patient learns that cancer has spread to her lymph nodes after receiving a pet scan.

Imaging in Medicine
The Science of Medical Imaging
Seeing More with PET Scans
The PET scan

Sample questions for students to investigate: 3-D learning opportunities:

- What is an isotope?
- How are "isotopes" of an element different from "atoms"?
  Develop a model to support your response.
- What determines if an isotope of an element is stable or radioactive?
- Why are some radioactive isotopes used in nuclear medicine and others are not?
- How is radioactive decay, like gamma rays, used to diagnose cancer?
- Can nonradioactive isotopes be used to diagnose cancer? Why or why not? Use evidence to support your response.
- What is the role of radioactive decay in nuclear processes?
- How are uranium isotopes used in nuclear processes?
- What radioactive particles are a bi-product of nuclear processes?
- Make a claim supporting or refuting the use of radioactive isotopes in medicine?
- Why did the Japanese people have a higher risk of developing cancer after the Fukushima Daiichi nuclear disaster?

SEP: Develop and use a model; Construct an explanation

DCI: HS.PS1A.a; HS.PS1A.b; HS.PS2B.c

CC: Energy and matter

Sample 3: Female factory workers contracted radiation poisoning from painting watch dials with selfluminous paint at the United States Radium factory.

NPR: One of the Last Radium Girls Dies at 107
90 Years Ago Workers at the Waterbury Clock Company began Dying
The Radium Girls
Sun and Other Types of Radiation
Phet: Alpha Decay
Phet: Beta Decay

Sample questions for students to investigate: 3-D learning opportunities:

- Where is radium located on the Periodic Table of Elements? What does the location of the element tell you about its reactivity and electronegativity and the relative size of its atoms? Use evidence from the Periodic Table of Elements to support your response.
- Why is radium a dangerous element? What type of radioactive particles are emitted by radium?
- How do radioactive materials- alpha, beta and gamma particles- obtain energy?
- Are all radioactive elements considered dangerous? Use evidence from the Periodic Table of Elements to support your response.
- What symptoms did the Radium Girls experience after digesting radium?
- What type of radioactive decay was emitted as a result of Fukushima Daiichi nuclear disaster? How did the emitted radioactive decay impact the Japanese community?

SEP: Develop and use a model; Construct an explanation

DCI: HS.PS1A.a; HS.PS1C.a; HS.PS2B.c

CCC: Patterns

Sample 4: On April 26, 1986, the world's worst nuclear power accident occurred at the Chernobyl nuclear power plant; it completely destroyed reactor four.

Nuclear Disaster at Chernobyl
Chernobyl: Facts about the Nuclear Disaster
Neighbors Diagnosed with Rare Cancer Years Later
Chernobyl Accident and Its Consequences
U.S. Energy Information Administration

Sample questions for students to investigate: 3-D learning opportunities:

- How are fission and fusion reactions different?
- What role do fission and fusion reactions play in powering power plants?
- Over the past 300 years, how have discoveries related to atomic structure affected life on our planet?
- How do economic, environmental, social and political factors affect the development and emergence of new nuclear technologies?
- How is nuclear energy regulated in the United States? 🎬 What is the role of a reactor is a nuclear power plant?
- Evaluate the following clip, CNN: Fukushima Disaster Zone. Make a claim supporting or refuting the use of nuclear energy in the United States or Louisiana. Use evidence to support your response.

SEP: Develop and use a model; Obtain, evaluate and communicate information; Analyze and interpret data

DCI: PS1.A.a; PS1C.a; PS2B.c; ETS1B.a; ESS2A.b

CCC: Energy and Matter

Sample Anchor Phenomenon Reflections

Communicate scientific reasoning around the anchor phenomenon

- How is the Periodic Table of Elements used to predict the relative properties of elements based on the patterns of valence electrons and the composition of the nucleus of atoms?
- How are the components of an atom's nucleus different during the process of fission, fusion, and radioactive decay?
- Evaluate the validity and reliability of claims about the viability of nuclear power as a source of alternative energy relative to other forms of energy (fossil fuels, wind, solar geothermal).

Sample Unit: Energy

This sample unit can be used to address standards that are not fully addressed by the sample scope and sequence provided on Page 6 of this document.

Performance Expectations

- HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
- HS-PS3-4: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
- HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Science and Engineering Practices

- Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Crosscutting Concepts

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Putting the Standards into Practice

Explore the anchor phenomenon

Sample Anchor Phenomenon: Heat from Earth's natural geologic processes can be used to make electricity.

Resources: A number of resources for the anchor phenomenon are included below. Teachers should screen the resources and pull photos, quotes, and data that are appropriate to share with high school students. These resources are not appropriate to be given to students as they are due to length, content, or accessibility of the content.

Energy 101: Geothermal Energy Video
PhET: Energy Forms and Changes Simulation
Geothermal Energy (National Geographic)
Can Geothermal Power Compete with Coal on Price? (Scientific American)
Geothermal Heat Pump Basics (U.S. Department of Energy)

Questions students may pose that could be used for future learning or investigations:

Try to make sense of the anchor phenomenon

- What is geothermal energy?
- How do geothermal power plants generate electricity?
- How do geothermal power plants capture energy from Earth's crust?
- Is geothermal energy a renewable or nonrenewable form of energy?
- How is thermal energy transferred between objects?
- What is the most efficient way to transfer thermal energy?
- Is thermal energy a conserved quantity?
- How is thermal energy transformed into electrical energy?
- What are the advantages and disadvantages of using geothermal energy?

Teachers should provide Investigative Phenomenon based on student observations, questions, and the Characteristics of Quality Investigative Phenomenon.

Sample Anchor Phenomenon Reflections

Communicate scientific reasoning around the anchor phenomenon

- Calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
- Design an experiment to verify that objects of different temperatures, when placed together, move towards a more uniform temperature distribution.
- Refine the design of a simple system that converts energy from one form to another.