Georgia Standards of Excellence in Science:

Frequently Asked Questions and Clarifications

The following list of questions and clarification statements have been collected since the new standards were first implemented during the 2017-2018 school year. A common practice to guide clarifications is to refer to *A Framework for K-12 Science Education*. This document served as a foundation for the Standards of Excellence.

Contents:

General Questions

QUESTION

What does "asking questions" look like for students in the classroom and on assessments in order to successfully master the standard?

RESPONSE

This question highlights the importance of using phenomena in science instruction. Students must be presented with an observable occurrence in order to help them develop questions that are related to the standard. We cannot expect students to ask specific questions related to a standard that will guide learning without somehow presenting a phenomenon first. Scientific questions arise in a variety of ways. They can be driven by curiosity about the world, inspired by the predictions of a model, theory, or findings from previous investigations, or they can be stimulated by the need to solve a problem. Scientific questions are distinguished from other types of questions in that the answers lie in explanations supported by empirical evidence, including evidence gathered by others or through investigation. In the classroom, student questions should guide instruction as students "figure out" the phenomenon presented. The questions should help as students construct explanations. In assessments, using a phenomena or scenario in the question or task can allow students to ask specific questions or possibly identify the most appropriate questions from a given list. For more on asking questions as a practice, see *A Framework for K-12 Science Education*.

Question

I need some clarification on the habits of mind from the GPS and the science and engineering practices. Also, should we be directly instructing the scientific method?

A Framework for K-12 Science Education discusses the myth of the existence of the "Scientific Method" and its relation to the science and engineering practices in Chapter 3 by saying, "A focus on practices (in the plural) avoids the mistaken impression that there is one distinctive approach common to all science -a single "scientific method." (*A Framework for K-12 Science Education*, p48). The idea in the GPS, and now reinforced in the GSE, is to engage the students in investigations by exposing them to phenomena that is both developmentally appropriate for them and relevant. Scientists do not always start by asking a question, creating a hypothesis and then setting the variables etc.

The importance of "habits of mind" is also addressed in Chapter 3 of *A Framework for K-12 Science Education*. The whole idea of engaging students in the science and engineering practices as one of the dimensions that make up the instructional model that you use is based in our understanding that these "habits of mind" are fundamental to make sense of the scientific knowledge that we seek our students to develop. In addition, engaging students in the use of the science and engineering practices will provide them with a better set of skills to develop solutions to problems and be more critical consumers of scientific information.

Encourage students to ask questions about the particular observation of phenomena that they may be interested in studying, analyze data, develop arguments and look at collecting evidence that may support or not support these arguments, construct explanations that use core scientific understandings (think laws, theories, or individual core disciplinary ideas), develop models, and engage in computational thinking to support their claims.

Second Grade

S2E2. Obtain, evaluate, and communicate information to develop an understanding of the patterns of the sun and the moon and the sun's effect on Earth.

a. Plan and carry out an investigation to determine the effect of the position of the sun in relation to a fixed object on Earth at various times of the day.
b. Design and build a structure that demonstrates how shadows change throughout the day.
c. Represent data in tables and/or graphs of the length of the day and night to recognize the change in seasons.
d. Use data from personal observations to describe, illustrate, and predict how the appearance of the moon changes over time in a pattern.

QUESTION

Should the Earth's rotation be taught with this standard? Or is this something that should just be mentioned to help students better understand the standard?

RESPONSE

What is it about the Earth's rotation that you want to teach? Do you want to tell the students that the Earth' rotates like a top around its axis? At this level students are not ready to understand causal relationships. The intent of this standard is to continue developing those skills that are natural for a second grader, i.e. observation.

A Framework for K-12 Science Education indicates that by the end of grade 2:

- Seasonal patterns sunrise and sunset should be observed, described, and predicted.
- Recognize that some events on Earth like day and night, occur in cycles.

Under the 2061 Framework for Science Literacy the expectations are:

- Students recognize that the moon looks a little different every day, but it looks the same again about every four weeks.
- Observe that the sun can be seeing only in the daytime, but the moon can be seen sometimes at night and sometimes during the day. The sun, moon, and stars all appear to move slowly across the sky.

All these expectations deal with observations and not with a causal relationship.

Third Grade

S3E1. Obtain, evaluate, and communicate information about the physical attributes of rocks and soils.

a. Ask questions and analyze data to classify rocks by their physical attributes (color, texture, luster, and hardness) using simple tests.
(*Clarification statement*: Mohs scale should be studied at this level. Cleavage, streak and the classification of rocks as sedimentary, igneous, and metamorphic are studied in sixth grade.)

QUESTION

What should the focus be for this standard?

RESPONSE

The focus of S3E1 has two key components; the focus on classification and the introduction to the core idea of physical properties. Rocks, and that includes minerals, are used just because is something concrete that the students can see, touch, and are familiar with. At this level of student development, the objective is to develop the skills necessary for students to use classification as a method to identify patterns that will later lead them to make claims, explanations or generalizations that could become laws.

Classifying rocks using physical properties that can be observed will not get them to differentiate between their process of formation, but that is okay at this level. Students are not ready to understand the rock cycle as they are still missing several core ideas like energy flow, energy transformations, relationships between pressure and energy, and plate tectonics. These are some of the reasons why the writers of the third-grade standards decided to include in the clarification statement that the classification of rocks due to their process of formation was left to sixth grade. An additional clarification for this standard is in relation to the distinction between minerals and rocks. The modern understanding of this core idea is that all minerals are rocks, but not all rocks are minerals.

Third Grade

S3L1. Obtain, evaluate, and communicate information about the similarities and differences between plants, animals, and habitats found within geographic regions (Blue Ridge Mountains, Piedmont, Coastal Plains, Valley and Ridge, and Appalachian Plateau) of Georgia.

a. Ask questions to differentiate between plants, animals, and habitats found within Georgia's geographic regions.
b. Construct an explanation of how external features and adaptations (camouflage, hibernation, migration, mimicry) of animals allow them to survive in their habitat.
c. Use evidence to construct an explanation of why some organisms can thrive in one habitat and not in another.

QUESTION

What should the focus be for this standard?

RESPONSE

The standard emphasis is in identifying similarities and differences between living organisms and habitats that are found within the different geographic regions of Georgia. As you look at differences and similarities of living organisms, you are looking at characteristics like the ones described in the second element under the standard, i.e., external features or adaptations that will allow these organisms to survive.

You could use any organism that you think your students are either familiar with or will be of interest to them to help them meet the expectations described in the standard. The standard is written in such a way that such selection is completely up to you and it is really irrelevant. For example, you could decide to talk about the characteristics of oak-hickory trees or the American Black Bear and how their characteristics allow them to thrive in the Blue Ridge Mountains region and probably would not be helpful in the Coastal Plains region. You could talk about different camouflage markings between organisms living in different regions or patterns of migration.

Note that the standard calls for students collecting information about geographic regions, their habitats, flora and fauna and to use this information to construct explanations of why some organisms live in a particular region while others do not. This is the essence of the standard. Again, which organisms you or your students decide to use is not critical. The important point is that their arguments are supported by evidence as to why the organisms they selected are well adapted for the region that they are describing. This is the key.

As for resources, a simple google search about Georgia regions can give you an idea of the organisms and description of the habitats that are present in those regions. For example, see the links below
http://www.virtualblueridge.com/nature-guide/wildlife/
http://www.georgiaencyclopedia.org/articles/geography-environment/blue-ridge-mountains
https://sites.google.com/site/georgiaregions/home
http://www.georgiaencyclopedia.org/articles/geography-environment/piedmont-geographic-region
http://www.fernbankmuseum.org/media/1360/2-3grade-wttghunt.pdf

QUESTIONS

1. We noticed on S3L1 that swamps and marshes are not included in the recommended GSE. Does this mean this part of the state including Okefenokee Swamp will be included in the Coastal Plains?
2. In the past, the swamp/marsh and Atlantic Ocean parts of the coastal plains were addressed as individual habitats and the three geographic mountain habitats were combined into one habitat region.

RESPONSE

Please note that swamps and marshes are not geographic regions but habitats. Note that S3L1a directly calls for working with the different habitats that are found within the different regions. Therefore, swamps and marshes should be addressed here when appropriate.

These definitions should help you with the distinction between a habitat and a region:

A habitat is an area or natural environment in which an organism or population normally lives. The *habitat* is made up of physical factors such as soil, moisture, range of temperature, and availability of light as well as biotic factors such as the availability of food and the presence of predators.

A region is an area that is identified by its physical characteristics, like such as drainage basins, mountain ranges, and soil types for example.

The Atlantic is not considered a geographic region of Georgia. The Atlantic is a marine region, an ocean, and it is classified as an aquatic biome. The standard does not call for addressing this region for students. It could be relevant if time allows. This region can also be left for later when students study biomes.

Fifth Grade

S5L1. Obtain, evaluate, and communicate information to group organisms using scientific classification procedures.

b. Develop a model that illustrates how plants are sorted into groups (seed producers, non-seed producers) using data from multiple sources

QUESTION

Under this standard and element, the clarification in the parentheses say seed producers, non-seed producers. Does that mean they will only talk about those or how plants can be grouped under those headings? What about vascular and non-vascular?

RESPONSE

Students are expected to sort between seed producers and non-seed producers ONLY. So, they are focusing on seed producers (have flowers that become fruits, nuts, or vegetables, or have cones) and non-seed producers (do not have flowers/cones - like ferns and mosses). While you may choose to introduce the terms gymnosperms and angiosperms when looking at seed producers, those terms would not be assessed as the standards states they classify between seed producers and non-seed producers. I might start with some pictures of various plants and have students look for the similarities and differences of the plants in the pictures. - *Describe each plant pictured. Do any of the plants in the picture seem more similar to or different from one another? If you had to place them in a group, how would you do that?* Introduce the language of seed producers and non-seed producers. Challenge students to find pictures of different kinds of plants and to use the physical characteristics of the different kinds of plants to sort them into like groups: Seed producer (has flower or cone), Non-seed producers with roots, stems and leaves (mosses and ferns), Non-seed producers without roots, stems and leaves (algae).

The writing group, in consultation with the seventh grade and biology writing groups considered the use of the terms “seed producers” and “non-seed producers” to be more developmentally appropriate for elementary school students. There is nothing that precludes using the terms “vascular” and “non-vascular”. However, the use of these terms implies that there will be a need to add understandings about plant structures. Does this provide any key understandings worthy of addressing now for the concepts to be addressed in seventh grade life science and/or high school biology? There are several key ideas that already need attention just in this standard i.e. the idea of classification and what characteristics determine how to classify organism based on scientific understandings. The practice of developing classification models will be required. In addition, there is the more extensive understandings of animal classification required in S5L1a.

Fifth Grade

S5P1. Obtain, evaluate, and communicate information to explain the differences between a physical change and a chemical change.

a. Plan and carry out investigations of physical changes by manipulating, separating and mixing dry and liquid materials.
b. Construct an argument based on observations to support a claim that the physical changes in the state of water are due to temperature changes, which cause small particles that cannot be seen to move differently.
c. Plan and carry out an investigation to determine if a chemical change occurred based on observable evidence (color, gas, temperature change, odor, new substance produced).

QUESTION

Should the study of this standard include physical and chemical properties specifically? Also, should students study the temperatures at which phase changes of water occur in Celsius and Fahrenheit?

RESPONSE

While there should not be a desire for students to memorize temperatures at this stage, it is a bit difficult not to discuss observations of specific temperatures when observing physical changes in water and constructing an argument that those changes are due to temperature changes. Students /teachers could say general descriptions like "as the temperature of the water increased, I noticed…." Or "when the water temperature decreased, I noticed…" without citing actual temperatures. Students should not be memorizing boiling point and freezing point and never make any real observations. They will forget those numbers and can easily google them when they need them. They need to observe changes in water and notice what happens in a "I will remember this forever" way – I can relate this change in water to the change in temperature. What is it we want students to observe? Not specific numbers on a thermometer. It could come in handy to repeat experiments/observations and to use those measurements to construct an argument. Generally, students should notice measurements just to understand the difference in say water at 30 degree Celsius and 100. But don't memorize temperatures. The big idea is for students to understand the differences between a physical and chemical change. Water is a cheap, readily accessible material that nicely shows physical changes. It is something all children have experience with. It will help them later with understanding weather, etc. Teachers could probably tear paper and do other things too to help drive home the point of what a physical change is. This element also talks about small particles that cannot be seen moving differently, so students need to understand visually how those small particles move when heated.

For chemical properties specifically things like flammability, reactivity is not required in this standard. In S5P1 c the focus is on observable evidence and lists color, gas, etc.

QUESTION

Is there any introduction to the Law of Conservation of Mass in 5th grade without the student asking questions about where the material goes?

RESPONSE

The standards do not expect a teacher to introduce the formal Law of Conservation of Matter at 5th grade. However, remember standards are written at the minimum for instruction and maximum for assessment. A teacher, depending on her students, may teach above the

standard. At this stage you are developing the foundation that 8th grade and high school will build upon. At this stage students may be collecting evidence as to whether matter still exists when it is not visible.
It is a good practice to go to the grade band endpoints in *A Framework for K-12 Science Education*. On pages 108, 110 and 233 for the endpoint progression for Grades 3-5, it does include that students understand the amount of matter is conserved when it changes form – even in transitions in which it seems to vanish (sugar in a solution). But at this level there is no attempt to define unseen particles or explain atomic –scale mechanisms of evaporation and condensation. It also states that by the end of 5th grade "no matter what reaction or change in properties occurs, the total weight of the substance does not change. (Boundary: Mass and weight are not distinguished at this grade level)." Because of that, it would okay to introduce it (but not necessary to have students learn the definition of the "Law of Conservation of Matter", and our GSE do not require it at 5th grade). As a part of S5P1a when "manipulating," students may be led to make this observation. But it really is an expectation, for us, at 8th grade.

Look in *A Framework for K-12 Science Education* for conservation of matter/mass/energy and expectations at each grade band. You may also want to go back and look at S2P1 and see how you are building on that standard. Also, look ahead at 8th which is also appropriate in determining what needs to be discussed in 5th.

When you look at our GSE, the main focus is on explaining the differences between physical and chemical changes.

Fifth Grade

S5P1. Obtain, evaluate, and communicate information to explain the differences between a physical change and a chemical change.

b. Construct an argument based on observations to support a claim that the physical changes in the state of water are due to temperature changes, which cause small particles that cannot be seen to move differently.

QUESTION

Under S5P1, the word particles is used in b. Wouldn't they also talk about atoms and molecules in this section?

RESPONSE

No, the ideas of atoms or molecules are not developmentally appropriate at this time. More about this can be read on the NRC published work "Taking Science To School: Learning and Teaching Science in Grades K-8" (You can download this work from https://www.nap.edu/read/11625/chapter/6#101) and look at the information presented starting on page 102.
By using the word particles, teachers avoid creating misconceptions about how a microscopic explanation of matter provides a model to understand the macroscopic phenomena that they are observing.

Fifth Grade

S5P2. Obtain, evaluate, and communicate information to investigate electricity.

a. Obtain and combine information from multiple sources to explain the difference between naturally occurring electricity (static) and human-harnessed electricity.

QUESTION

Are fifth grade teachers supposed to teach proton, electron and neutron information when they study the difference in static electricity and man-made electricity, or should the kids just know that static electricity builds up in one place and man-made current travels along a path?

RESPONSE

In looking at the overarching standard and all the elements and reading the framework grade band endpoints (*A Framework for K-12 Science Education*), students at 5th grade need to know that static electricity builds up in one place and man-made current travels along a path, but it is really challenging to talk about static without talking about charges and thus electrons and protons. The resources that were developed for 5th grade do explain this at a fairly basic level and do introduce charge/electron flow etc. But as the standard notes, we are explaining differences between the two; the bigger idea here is naturally occurring/static/builds up in place and human-harnessed/current/travels along a man-made circuit. We move to deeper atomic-level explanations in 8th grade. Teachers almost have to introduce these particles in 5th grade to explain charge imbalance and static electricity, but students do not need to have a deep understanding. Also, the science practices in S5P2 should lead students to play and observe what happens when you rub a balloon on your hair and then the wall vs building a circuit using a battery and wire.

Sixth Grade

S6E3. Obtain, evaluate, and communicate information to recognize the significant role of water in Earth processes.

d. Analyze and interpret data to create graphic representations of the causes and effects of waves, currents, and tides in Earth's systems.

QUESTION

What is meant by "create graphic representations"—does that literally mean graphs and charts? In which case I struggle with how to create a graph that represents causes and effects—what would that look like? Or does "graphic representations" just mean drawings/models?

RESPONSE

Yes, it means that students analyze data to create graphs. For example, students can graph tide height vs. moon phases or relative position, or ocean current vs. water density, etc. These graphs represent cause and effect relationships. Actually, all graphs that are created in science are cause and effect relationships. That is what students plot when you look at relationships between independent and dependent variables in any experiment.

Here are some sites that deal with these phenomena
https://www.nodc.noaa.gov/gocd/category.html (Ocean Currents)
http://oceancurrents.rsmas.miami.edu/data.html (Ocean Currents)
https://tidesandcurrents.noaa.gov/education.html (Tides and Currents)
https://tidesandcurrents.noaa.gov/faq2.html (Tides)
https://middleschoolscience.com/2015/02/10/graphing-spring-tides-neap-tides-moon-phases/ (moon phases and tides)

QUESTION

What kind of data should be interpreted that is going to lead students to see the causes and effects of waves, currents, and tides? For example, we could look at tide time tables or maybe tide height, but that doesn't really tell us the cause of a tide.

RESPONSE

See examples above. You could over impose the moon phases or the moon's relative position to your time vs. height graph to identify a relationship.
Some ideas on how to do this can be found on these sites
https://middleschoolscience.com/2015/02/10/graphing-spring-tides-neap-tides-moon-phases (moon phases and tides)
https://middleschoolscience.com/2015/02/01/using-real-time-data-noaa-tides (moon phases and tides)

Sixth Grade

S6E4. Obtain, evaluate, and communicate information about how the sun, land, and water affect climate and weather.

b. Plan and carry out an investigation to demonstrate how energy from the sun transfers heat to air, land and water at different rates.

(*Clarification statement:* Heat transfer should include the processes of conduction, convection, and radiation.)

QUESTION

How can we teach this standard if there is no longer "metrics" specifically addressed like the GPS used to have in the co-requisites?

RESPONSE

If students are demonstrating this through an experiment, they will encounter thermometers/degree scales and maybe both digital and analog meters. If students have not seen certain units or equipment—what a good place to learn about it when it is ***in context***, with an experiment/phenomenon. When looking at the practice of planning and carrying out investigations, it is acceptable to expect that 6th graders would consider how data would be presented and units or scales. Students need to be actively engaged in obtaining, evaluating and communicating.

For "explicit direction" of materials or methods, this happens ***in context*** while students are engaged with the science practice and a phenomenon.

In this standard, there could be a valuable exercise of using Fahrenheit and Celsius thermometers at the same time to measure how something is warmed by the sun. Let the students figure out that different groups recorded different numbers for the same object. Some students may feel they measured wrong or that groups messed up, but wouldn't it be valuable learning for them when the teacher says, "You're both correct?" That would be a great time to bring in temperature scales.

It is important to remember that data can be collected in different ways and using different instruments. These instruments will sometimes use different scales to measure things. As part of working with students in developing the skill of collecting data, it is important to work with them on learning how to properly use the instrument that they are using. This means paying attention not just to the numerical value reading but also to the units in which this value makes sense. Developing this skill is independent of any set of units whether the units are metric or any other.

The practice of analyzing and interpreting data comes up frequently in 6th science; this encompasses so much of the previous characteristics of science. All data is not the same; in this course 6th graders will see different scales, units, and possibly new measurements, but the science practice is how students will engage with core ideas as they explain a phenomenon. Data and measurements are not the end result, but a step in the process and some students will need more support than others.

Additionally, metrics is addressed in 6th grade mathematics.

Each GSE science standard and element starts with one of the eight science and engineering practices from *A Framework for K-12 Science Education*. An additional resource for the science and engineering practices are these videos.

Sixth Grade

S6E5. Obtain, evaluate, and communicate information to show how Earth's surface is formed.

c. Construct an explanation of how to classify rocks by their formation and how rocks change through geologic processes in the rock cycle**.**

QUESTION

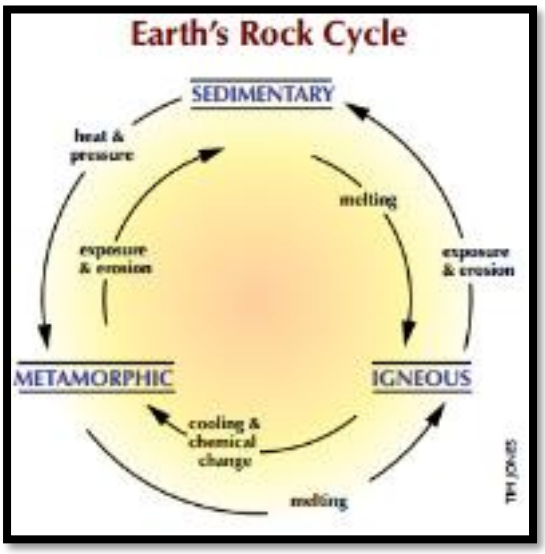
How deep into classification of rocks by their formation do we need to go? For example, should students be able to explain how specific types of igneous rock are formed? Or specific types of sedimentary rock? Or should they just be able to differentiate between the 3 major types of rock?

RESPONSE

First consideration… Do students have time to engage in argumentation leading to their understanding and formation of explanations about specific mechanisms for rock formation that will result in different types of igneous, sedimentary or metaphoric rocks? Just remember this is not a rock course. It is a general Earth science course that is addressing a great number of core ideas.

Recommendation…First, the focus should be on the core idea here, and that is the rock cycle:

1. Solid rock is formed by the cooling of molten rock, the accumulation and consolidation of sediments, or the alteration of older rocks by heat, pressure, and fluids.
2. The energy powering the rock cycle comes from the sun and the Earth's core.
3. The rock cycle is an example of the cycling of Earth's materials.



Students should be able to construct explanations using the diagram to the left to explain the process of formation of different types of rocks and the idea of how this process represent the cycling of matter and is driving by the flow of energy in a system. Students should be able to construct explanations that describe how different mechanisms, i.e., pressure, heat, erosion and weathering are responsible for the formation of different types of rocks.

Seventh Grade

S7L1. Obtain, evaluate, and communicate information to investigate the diversity of living organisms and how they can be compared scientifically.

a. Develop and defend a model that categorizes organisms based on common characteristics.

QUESTION

Can you provide examples of such a model because this is very vague?

RESPONSE

For seventh grade students, developing models could include activities where students have a collection of organisms (samples, pictures, etc.) and then develop an organizational chart based on common characteristics. The importance of the science practice here is that students are making and defending models and are not just being given charts or tables. Students might organize different organisms by appearance, by size, where it lives, and many other characteristics. The "defend" aspect of the practice could present in the classroom as students discussing in groups how they organized the samples. Students may develop different models for the same group of organisms.

S7L1. Obtain, evaluate, and communicate information to investigate the diversity of living organisms and how they can be compared scientifically.

b. Evaluate historical models of how organisms were classified based on physical characteristics and how that led to the six kingdom system (currently archaea, bacteria, protists, fungi, plants, and animals).
(*Clarification statement:* This includes common examples and characteristics such as, but not limited to, prokaryotic, eukaryotic, unicellular, multicellular, asexual reproduction, sexual reproduction, autotroph, heterotroph, and unique cell structures. Modern classification will be addressed in high school.)

QUESTIONS

Does "evaluate" imply that we ask students to consider how effective this system is with regards to identification?

How in-depth do we go having students recognize characteristics of certain phyla?
What exactly does the clarification statement mean by "unique cell structures?"

RESPONSE

As students evaluate historical models, they are seeing how new information has changed how scientists organize organisms. A historical approach might examine how Aristotle had two categories: animals and plants and subgroups of each. Linnaeus developed a system of kingdoms with five levels of organization each. Students could learn about how archaea was categorized. Students are not required to memorize phyla but should have some experience with kingdom organization. Unique cell structures could be chloroplasts or flagella, or others.

Seventh Grade

S7L2. Obtain, evaluate, and communicate information to describe how cell structures, cells, tissues, organs, and organ systems interact to maintain the basic needs of organisms.

d. Develop and use a conceptual model of how cells are organized into tissues, tissues into organs, organs into systems, and systems into organisms.

QUESTION

We are in a debate about how deeply we should go on the tissues. Should we go into the diversity of the tissue types? Epithelial, connective, muscle, and nervous, or not?

RESPONSE

It is helpful to refer to *A Framework for K-12 Science Education* which our GSE writers used as they revised standards (download for free from the National Academies Press). On page 144 it says, "By the end of grade 8...In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues or organs that are specialized for particular body functions. (Boundary: At this grade level, only a few major cell structures should be introduced.)"
It is also helpful to see what the expectation is for the end of high school.

The emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body function. Examples could include the interaction of a subsystem within a system and the normal functioning of those systems. If there was a state assessment, it would not include the mechanism of one body system independent of others.

When looking at national standards, they address it this way (realize their standard is different in terms of the practice):
Students identify and describe* the given evidence that supports the claim (e.g., evidence from data and scientific literature), including evidence that: i. Specialized groups of cells work together to form tissues (e.g., evidence from data about the kinds of cells found in different tissues, such as nervous, muscular, and epithelial, and their functions). ii. Specialized tissues comprise each organ, enabling the specific organ functions to be carried out (e.g., the heart contains muscle, connective, and epithelial tissues that allow the heart to receive and pump blood). iii. Different organs can work together as subsystems to form organ systems that carry out complex functions (e.g., the heart and blood vessels work together as the circulatory system to transport blood and materials throughout the body). iv. The body contains organs and organ systems that interact with each other to carry out all necessary functions for survival and growth of the organism (e.g., the digestive, respiratory, and circulatory systems are involved in the breakdown and transport of food and the transport of oxygen throughout the body to cells, where the molecules can be used for energy, growth, and repair).

Students should understand that tissues are specialized, etc. But they do not have to memorize every single system. They need a conceptual understanding.

S7L2. Obtain, evaluate, and communicate information to describe how cell structures, cells, tissues, organs, and organ systems interact to maintain the basic needs of organisms.

e. Construct an argument that systems of the body (Cardiovascular, Excretory, Digestive, Respiratory, Muscular, Nervous, and Immune) interact with one another to carry out life processes. (*Clarification statement:* The emphasis is not on learning individual structures and functions associated with each system, but on how systems interact to support life processes.)

QUESTION

This standard addresses how systems of the body interact with one another to carry out life processes, but why does it not specifically state the Skeletal System in the mentioning of body systems?

RESPONSE

Standards are written at a minimum for instruction and a maximum for assessment. If the State assessed this item, it would not ask about the skeletal system. However, standards do not limit learning. Teachers could possibly spend too much time teaching the bones in great detail, but this standard is not about that. Time is also a concern based on the amount of information already listed in the standard.

The big idea is to look at interactions between systems, which is a pretty big task. If assessed, the students should understand the systems listed in the standard. The clarification statement here is very important:
The emphasis is not on learning individual structures and functions associated with each system, but on how systems interact to support life processes.

Per *A Framework for K-12 Science Education (Page 145):*

By the end of grade 8. All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). Unicellular organisms (microorganisms), like multicellular organisms, need food, water, a way to dispose of waste, and an environment in which they can live.

Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues or organs that are specialized for particular body functions. (Boundary: At this grade level, only a few major cell structures should be introduced.)

Seventh Grade

S7L3. Obtain, evaluate, and communicate information to explain how organisms reproduce either sexually or asexually and transfer genetic information to determine the traits of their offspring.

a. Construct an explanation supported with scientific evidence of the role of genes and chromosomes in the process of inheriting a specific trait.

b. Develop and use a model to describe how asexual reproduction can result in offspring with identical genetic information while sexual reproduction results in genetic variation. (*Clarification statement:* Models could include, but are not limited to, the use of monohybrid Punnett squares to demonstrate the heritability of genes and the resulting genetic variation, identification of heterozygous and homozygous, and comparison of genotype vs. phenotype.)

c. Ask questions to gather and synthesize information about the ways humans influence the inheritance of desired traits in organisms through selective breeding. (*Clarification statement:* The element specifically addresses artificial selection and the ways in which it is fundamentally different from natural selection.)

QUESTION

Quick question on meiosis and mitosis. Are these taught at the 7th grade level? I see them explicitly mentioned in Biology standard SB1b; however, S7L2 and 3 don't mention it specifically. Are we not going into those specific processes at the 7th grade level anymore?

RESPONSE

The process of looking to biology is right on target. In addition, the grade band endpoints for LS1B in *A Framework for K-12 Science Education* (p. 146 and p.158) is helpful. In this case, covering these processes is allowable but not required or necessary. The focus should not be about the steps in 7th grade. In S7L3, it could be relevant but not the key part (maybe basic understanding of the processes but not memorizing the steps). Students are developing the idea of organisms reproducing sexually or asexually and characteristics of inherited traits but not treating reproduction with great detail - not so much of the mechanics. Per the Framework, and the intent of the GSE writers, mitosis and meiosis is intended to be an expectation of high school.

Seventh Grade
S7L5. Obtain, evaluate, and communicate information from multiple sources to explain the theory of evolution of living organisms through inherited characteristics. a. Use mathematical representations to evaluate explanations of how natural selection leads to changes in specific traits of populations over successive generations. (*Clarification statement:* Referencing data should be obtained from multiple sources including, but not limited to, existing research and simulations. Students should be able to calculate means, represent this data in a table or graph, and reference it when explaining the principles of natural selection.)
QUESTION What does this standard mean by mathematical models?
RESPONSE Here we are looking for students to use computer simulations or simulation models. For example, a simulation could be to run using pieces of paper of different colors thrown randomly on a background that makes one of the colors difficult to see. Students could pick up, in a certain amount of time, all pieces of paper that they can, put them aside and collect the ones left on the table to repeat the process. Students may be collecting data and plotting this data to show a change in the characteristic of the population, color in this case.

Eighth Grade

S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter.

a. Develop and use a model to compare and contrast pure substances (elements and compounds) and mixtures.
(*Clarification statement:* Include heterogeneous and homogeneous mixtures. Types of bonds and compounds will be addressed in high school physical science.)

QUESTION

I wanted to double check something regarding the new standards. I know in the chemistry realm we need to really hit conservation of matter and molecules. One of the clarification statements mentions that "types of bonds and compounds will be covered in high school". In the past, we have introduced ionic and covalent bonds, but from what I can tell from the new standards it might be superfluous information.

RESPONSE

The focus of the standard should be in the properties that are observable on a given scale, and how those properties can be used to make comparisons between pure substances and mixtures. Comparing and contrasting bonding structure is not included in this standard; however, bonds could represent models of a pure substance, or elements could represent a mixture. Being able to identify a bond type is not the intent of this standard.

S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter

e. Develop models (e.g., atomic-level models, including drawings, and computer representations) by analyzing patterns within the periodic table that illustrate the structure, composition, and characteristics of atoms (protons, neutrons, and electrons) and simple molecules.

QUESTION

Do we need to discuss how the structure of an atom determines is chemical properties and the fact that is unreactive or reactive? So, am I correct in assuming that we need to be very general in terms of atomic bonding (they need to bond in order to be stable and have full electron shells) and not so much the terms and different types of bonds?

RESPONSE

The focus of the standards is on structure and properties of matter; one of the elements under this standard is about conservation of matter but that is not the only focus. In S8P1e, the information in the parenthesis should hint that the focus should be in the structure of atoms as it relates to number of electrons, protons, and neutrons and their location within the general atom. In the case of the simple molecules part, it is more about recognizing that H_2O means that there are two hydrogen atoms bonded to one oxygen atom or that NaCl means that one atom of sodium is bonded to one atom of chloride for example. There is no need to explain the type of bonds that makes this union possible.

As for the chemical property of reactivity, this can be treated without any understanding of the type of bond that an element may or may not form or any understanding about the electronic shells being completed or not when forming a molecule. Again, the idea is that there is a pattern in the periodic table that can be used to get an idea if an element is more reactive than another by the position that the element occupies in the periodic table.

S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter f. Construct an explanation based on evidence to describe conservation of matter in a chemical reaction including the resulting differences between products and reactants. (*Clarification statement:* Evidence could include models such as balanced chemical equations.)
QUESTION Do we need to have students know how to actually balance chemical equations, or just be able to identify whether an equation is balanced or unbalanced?
RESPONSE The focus of this standard should be on students engaged with the science practice of constructing explanations based on evidence of conservation of matter. Evidence could include data generated from a chemical reaction or experiment, such as baking soda and vinegar in closed or open containers while measuring mass. Students should be to explain why a given equation might be balanced or not.

Eighth Grade
S8P2. Obtain, evaluate, and communicate information about the law of conservation of energy to develop arguments that energy can transform from one form to another within a system. a. Analyze and interpret data to create graphical displays that illustrate the relationships of kinetic energy to mass and speed, and potential energy to mass and height of an object.
QUESTION Should students be able to calculate potential & kinetic energy?
RESPONSE No, the element does not require students to calculate potential or kinetic energy but only to develop a phenomenological understanding of the relation between the kinetic energy of an object and its mass and velocity and the potential energy of an object and the idea of its relative position respect to a particular reference frame (in most cases this will be its height as the reference frame is more often selected as the ground) and its mass. In other words, expecting that students recognize that objects with larger masses and moving at higher speeds have more kinetic energy than those that have less masses and are moving at a slower speed and that objects at higher heights and with larger masses have more potential energy than those at lower heights and smaller masses. Note that the word "calculation" is not part of the element.
S8P2. Obtain, evaluate, and communicate information about the law of conservation of energy to develop arguments that energy can transform from one form to another within a system. c. Construct an argument to support a claim about the type of energy transformations within a system [e.g., lighting a match (light to heat), turning on a light (electrical to light)].
QUESTION

Which types of energy will be tested? Will chemical, geothermal, mechanical and nuclear or only light, heat and electrical that are named in the standard be tested? Do the students need to know thermal for heat, electromagnetic for light?

RESPONSE

It is helpful to look at the standard in its entirety. The core disciplinary idea of the standard is to develop an understanding of the law of conservation of energy. The idea of conservation of energy implies that energy must transform from one form to another to be "useful". Humans for example, would not be here if light (electromagnetic energy) were not used by producers to drive mechanisms that recombine the constituents of different molecules (atoms) into new configurations (new molecules).

The element mentioned here, does not eliminate any form of energy from discussion. The point is that as students describe the energy transformations that take place on a given process; they do this mainly by constructing arguments to support their claims (the transformations identified in the process being studied). An argument always responds to the question How do I know? Not to Why is that so?

Therefore, all the forms of energy mentioned could be used on any scenario that students maybe studying.

QUESTION

In the transformation of energy in lighting a match, I would say chemical to light and heat or should it be light to heat?

RESPONSE

This is a very good example of how saying energy is transformed from chemical to light or from heat to light is not enough. There needs to be an argument to support the claim. You could say that the energy transformation is from chemical to light if you think that light is the direct result of the excitation of electrons in the phosphorous atoms (this could be chemical if you explain this as the oxidation of the phosphorus atoms that changes them to a different form). However, you could also consider that the light that is the result of this process is radiation energy that will feel to the observer as thermal energy).

Eighth Grade

S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves.

g. Develop and use models to demonstrate the effects that lenses have on light (i.e., formation an image) and their possible technological applications.

QUESTION

What is expected of students for this standard?

RESPONSE

It is important to point out the science practice in this element. It is the expectation that *students* will be developing and using models about how light is affected with lenses. Models can include drawings, diagrams, ray diagrams, lens projections, etc. Since students are developing the models (and not just given descriptions or definitions) there should be a hands-on component or simulation where students might have direct experience with how light changes with lenses. In addition, students should gain an understanding of how images, real

and virtual, can be formed and magnified. Given a model or diagram of an object and lens, students should be able to predict image type and location. Students are not expected to calculate variables associated with the thin lens equation as this will be covered in high school physics.

Eighth Grade

S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature.

b. Plan and carry out investigations to demonstrate the distribution of charge in conductors and insulators.
(*Clarification statement:* Include conduction, induction, and friction.)

QUESTION

There is no mention of circuits in our new standards. I have taken this standard to explicitly mean direct teaching of static charge rather than electric current. One of my colleagues is not as certain. Are circuits officially no longer a part of the 8th grade GSE?

RESPONSE

Indeed, circuits are not part of the standard. The focus on this element is on creating a solid understanding on charge distribution and movement in conductors and insulators. With the science and engineering practice for this standard, students should be investigating distribution of charge. The clarification statement refers to ways in which an object can be charged and hints to the idea that the distribution of charge that results from each one of these processes is different and depends of the material being a conductor or an insulator.

QUESTION

The standards are confusing about whether it's supposed to be just about static electricity or whether electric current/the flow of electricity should also somehow be included. Can you please clarify?

RESPONSE

The standard focus on the idea of charge distribution not of current or flow of electric charge. Materials, depending if they are conductors or insulators will exhibit different behavior in the way that electric particles are distributed in them and in the way that the distribution of these electric particles changes when the material is charged (or discharged) by conduction, induction or by friction. For example, think in a metallic sphere (a conductor) that does not have any net charge on it (a grounded sphere for example). If a charged object (let's assume that is positively charged) is moved in closer to the sphere without touching it, the metallic sphere's charges will rearrange in such a way that the side of the sphere near the charged object will have an excess of negative charges and the side of the sphere farthest away will have an excess of positive charges. It is the rearranging of charge distribution that is being addressed in this particular element.

Biology

SB1. Obtain, evaluate, and communicate information to analyze the nature of the relationships between structures and functions in living cells.

b. Develop and use models to explain the role of cellular reproduction (including binary fission, mitosis, and meiosis) in maintaining genetic continuity.

QUESTION

Do students need to understand the steps of mitosis and meiosis?

RESPONSE

The memorization of the steps in either process is not the intent of this standard. The focus is on understanding of these processes and how they maintain genetic continuity. They need to know what is happening in the steps and be able to apply it to the process – "develop and use models to explain cellular reproduction." The focus should be on the following points:

1. Mitosis is a form of cell reproduction that results in two cells that are genetically identical to each other and to the original cell.
2. The importance and role of mitosis is dependent if the organism is unicellular or multicellular. In unicellular organisms, mitosis drives asexual reproduction while in multicell organisms the main role of mitosis is to produce more cells for growth and repair.
3. Because mitosis creates similar cells to the original cell, it occurs only in non-sex cells.
4. Meiosis is necessary for sexual reproduction to occur.
5. Through meiosis a cell (called a germ) splits to make four new sex cells, each with half the number of chromosomes as the original cell.
6. Reproduction by meiosis causes that each one of the four sex cells that result will have a unique combination of DNA.
7. The diversity within a population is a direct result of meiosis.

Per *A Framework for K-12 Science Education (page 147):*

By the end of grade 12. In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. As successive subdivisions of an embryo's cells occur, programmed genetic instructions and small differences in their immediate environments activate or inactivate different genes, which cause the cells to develop differently—a process called differentiation. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. In sexual reproduction, a specialized type of cell division called meiosis occurs that results in the production of sex cells, such as gametes in animals (sperm and eggs), which contain only one member from each chromosome pair in the parent cell.

Biology

SB1. Obtain, evaluate, and communicate information to analyze the nature of the relationships between structures and functions in living cells.

c. Construct arguments supported by evidence to relate the structure of macromolecules (carbohydrates, proteins, lipids, and nucleic acids) to their interactions in carrying out cellular processes.

QUESTION

Do the following topics need to be addressed: adhesion, cohesion, hydrogen bond, polarity, and solubility? How deep do teachers need to get into the properties of water?

RESPONSE

Water is not a macromolecule. While it plays a role in the macromolecule functioning, the standard SB1c is focusing more on cellular processes (structure/function of macromolecules). While cell reactions take place in solutions, the specific properties of water are not necessary to understand macromolecules. Cohesion and adhesion are an extension of hydrogen bonding and would apply to other concepts like water movement (capillary action) and not so much for cell function.

The question about properties of water fits more into:
SB1d Plan and carry out investigations to determine the role of cellular transport (e.g., active, passive, and osmosis) in maintaining homeostasis.

With this standard, students should have an understanding of concentration and how it impacts transport. Solubility and bond polarity could be discussed, but students being able to explain why water is polar and predict solubility is more along the lines of chemistry standards. It is important to point out that the science practice in this standard engages students with an investigation. Specific understandings of water properties (solubility rules, bond polarity) are not required to carry out an investigation of cellular transport. Phenomena used here could include a dialysis tubing set-up or viewing elodea under high power before and after soaking in different solutions.

SB1. Obtain, evaluate, and communicate information to analyze the nature of the relationships between structures and functions in living cells.

c. Construct arguments supported by evidence to relate the structure of macromolecules (carbohydrates, proteins, lipids, and nucleic acids) to their interactions in carrying out cellular processes.
(*Clarification statement*: The function of proteins as enzymes is limited to a conceptual understanding.)

QUESTION

In Biology Standard SB1c, I would like to clarify which level of conceptual understanding the clarification statement is referring to, as conceptual usually refers to a deeper level of understanding.

RESPONSE

Teachers should organize instruction around relationships between structure and functions in living cells. There is concern that teachers may be getting too far into enzymes; thus, the writers intended for the clarification statement to limit student understanding to conceptual only and not the individual specifics of *enzyme* structure/function; the use of "limited" is important to focus on. When looking at the standard and element together, the focus is more

along the lines of structural roles (helping keep the cell's shape), regulatory, repair, cell division, and enzymes. A few focus points for enzymes when considering the whole standard follow:

- Enzymes are proteins
- Enzymes make it possible (as catalysts) for reactions to take place that otherwise would not happen, due to a higher temperature damaging cell or it taking too long.
- Enzymes are specific shapes (lock and key analogy)
- Enzymes can be specific for an environment (low pH to work in stomach; high pH to work in intestine); other conditions, temperature, concentration can affect enzyme reaction

Specifics, such as how substrate binding works, induced-fit, cofactors, coenzymes, and inhibitors, are beyond the standard's intentions.

Our standard writers used our GPS, the survey responses, and *A Framework for K-12 Science Education*. Here are a couple excerpts (page 145) that are related to this standard:

"Special structures within cells are also responsible for specific cellular functions. The essential functions of a cell involve chemical reactions between many types of molecules, including water, proteins, carbohydrates, lipids, and nucleic acids. All cells contain genetic information, in the form of DNA. Genes are specific regions within the extremely large DNA molecules that form the chromosomes. Genes contain the instructions that code for the formation of molecules called proteins, which carry out most of the work of cells to perform the essential functions of life. That is, proteins provide structural components, serve as signaling devices, regulate cell activities, and determine the performance of cells through their enzymatic actions

By the end of grade 12. Systems of specialized cells within organisms help them perform the essential functions of life, which involve chemical reactions that take place between different types of molecules, such as water, proteins, carbohydrates, lipids, and nucleic acids."

For all students taking general biology, the standard is written at the minimum for instruction, for all students, meaning that depending on your students, their interests etc. teachers can certainly teach beyond the standard. Teachers should not feel limited. When students are expected to ask questions, use phenomenon, plan and conduct experiments, the world is opened and gives students some power in the direction of their learning. Of course, the teacher has to make the connections explicit, moderate those journeys, and teach all the standards required etc. The writers put the clarification statement there to help guide teachers in understanding that they do not have to go too far down the enzyme path.

QUESTION

For the structure of macromolecules is knowing the building blocks for each enough?

RESPONSE

A student understanding of the building blocks of the macromolecules is necessary in relating the structure of the molecule to the interactions within the cell. When looking at the standard and elements together, the focus is more along the lines of structural roles (helping keep the cell's shape), regulatory, repair, cell division, and enzymes. The standard focuses on the

identification of general common characteristics for each type of molecule and the ability of the student to use these to differentiate molecules and their complete specific functions. For example, by looking at the structure students should realize that carbohydrates have a simple structure formed by a backbone chain of carbon atoms to which oxygen atoms, hydrogen atoms, and hydroxide groups are attached. This simple structure allows for these molecules to be broken down and easy to metabolize. Specifics, such as how substrate binding works, induced-fit, cofactors, coenzymes, and inhibitors, are beyond the standard's intentions.

Per *A Framework for K-12 Science Education (page 145):*

"**By the end of grade 12**. Systems of specialized cells within organisms help them perform the essential functions of life, which involve chemical reactions that take place between different types of molecules, such as water, proteins, carbohydrates, lipids, and nucleic acids. All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.

Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Outside that range (e.g., at a too high or too low external temperature, with too little food or water available), the organism cannot survive. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system."

Biology

SB2. Obtain, evaluate, and communicate information to analyze how genetic information is expressed in cells.

b. Construct an argument based on evidence to support the claim that inheritable genetic variations may result from:

- new genetic combinations through meiosis (crossing over, nondisjunction)
- non-lethal errors occurring during replication (insertions, deletions, substitutions); and/or
- heritable mutations caused by environmental factors (radiation, chemicals, and viruses).

QUESTION

Do we need to cover karyotypes?

RESPONSE

While Karyotypes are not mentioned specifically in the standards, they could serve as model to discuss inheritance patterns related to nondisjunction. The karyotype would be evidence of the inheritable genetic variation possible. The karyotype by itself does not explain what went wrong during meiosis, so students should explore more in detail and focus on the science practice of constructing an argument.

Biology

SB3. Obtain, evaluate, and communicate information to analyze how biological traits are passed on to successive generations.

b. Use mathematical models to predict and explain patterns of inheritance. (*Clarification statement:* Students should be able to use Punnett squares (monohybrid and dihybrid crosses) and/or rules of probability, to analyze the following inheritance patterns: dominance, codominance, incomplete dominance.)

QUESTION

It is necessary to teach pedigrees in biology?

RESPONSE

Using *A Framework for K-12 Science Education* as a reference, there are two key questions that students should answer by addressing this standard; one is to explain how are characteristics of one generation passed to the next? And the second one is to explain how can individuals of the same species and even siblings have different characteristics? Therefore, there are two ideas that need attention, what will students need to predict patterns of inheritance and how will they need to be able to explain these patterns?

The standard directly requires students to predict patterns of inheritance, and they should be able to analyze the information contained in models like Punnett squares. Although, pedigree analysis is not mentioned in this element, pedigree analysis is a model used to study the inheritance of particular characteristics when progeny data from several generations is limited or when the study involves species with long generation time intervals. Therefore, pedigree analysis is part of the expectation set by using models to predict patterns of inheritance.

QUESTION

Do we need to cover sex-linked traits?

RESPONSE

The focus of this standard is to explain patterns of inheritance that result from dominance, codominance, and incomplete dominance processes by the use of models and the use of probability. Sex-linked traits can still follow inheritance patterns that students should have experience with. The intent is not for students to memorize what common traits are sex-linked or not, but for them to use models and data to make predictions about inheritance.

QUESTION

Are multiple alleles supposed to be addressed?

RESPONSE

In this element, students are using models, such as Punnett squares, to predict and explain inheritance patterns. This might involve simplifying at times the actual inheritance patterns and processes for student understanding. SB3b does specifically mention dominance, codominance, and incomplete dominance—all of which can be modeled without using traits that have multiple alleles. This topic could be addressed but would be an extension of the standard.

Biology

SB5. Obtain, evaluate, and communicate information to assess the interdependence of all organisms on one another and their environment.

a. Plan and carry out investigations and analyze data to support explanations about factors affecting biodiversity and populations in ecosystems.
(*Clarification statement:* Factors include size, carrying capacity, response to limiting factors, and keystone species.)

b. Develop and use models to analyze the cycling of matter and flow of energy within ecosystems through the processes of photosynthesis and respiration.
- Arranging components of a food web according to energy flow.
- Comparing the quantity of energy in the steps of an energy pyramid.
- Explaining the need for cycling of major biochemical elements (C, O, N, P, and H).

c. Construct an argument to predict the impact of environmental change on the stability of an ecosystem.

d. Design a solution to reduce the impact of a human activity on the environment.
(*Clarification statement:* Human activities may include chemical use, natural resources consumption, introduction of non-native species, greenhouse gas production.)

e. Construct explanations that predict an organism's ability to survive within changing environmental limits (e.g., temperature, pH, drought, fire).

QUESTION

Are the topics biomes, species interaction and ecological succession included?

RESPONSE

Succession would still be addressed here. When talking about fires and drought as in part e, students would likely talk about succession. The language of this standards is focusing on ecosystems. Is it okay to then discuss "biomes"? Sure, but is there going to be a question asking student to identify/list the biomes…no. Looking at this standard as a whole, students are looking at all those delicate relationships that can be found within an ecosystem. Species interactions are also a part of this standard. The language used in *A Framework for K-12 Science Education* is "ecosystem." The core idea LS2:

Ecosystems: Interactions, Energy, and Dynamics

How and why do organisms interact with their environment and what are the effects of these interactions?

Biology

SB5. Obtain, evaluate, and communicate information to assess the interdependence of all organisms on one another and their environment.

b. Develop and use models to analyze the cycling of matter and flow of energy within ecosystems through the processes of photosynthesis and respiration.
- Arranging components of a food web according to energy flow.
- Comparing the quantity of energy in the steps of an energy pyramid.

- Explaining the need for cycling of major biochemical elements (C, O, N, P, and H).

QUESTION

Do students need to know the entire Carbon, Phosphorus, and Nitrogen cycles (such as ammonification, nitrification, denitrification) or do students just need to understand there are cycles that these essential elements go through?

RESPONSE

Understanding how the inputs and outputs relate to photosynthesis and respiration is important here. The science practice of developing and using models means that the students will be identifying that at some point on the nitrogen cycle, bacteria or fungi will convert the nitrogen stored in a dead organism for example back into ammonium. There is no need to identify this process as the ammonification phase of the cycle or to identify how this process occurs, but it is important that the students are aware that this step takes place. Similar understanding applied to the nitrification and denitrification process. Students could use given models to explain why there is nutrient cycling.

Per *A Framework for K-12 Science Education (page 154):*
"**By the end of grade 12**. Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web, and there is a limit to the number of organisms that an ecosystem can sustain.

The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil and are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved; some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. Competition among species is ultimately competition for the matter and energy needed for life.

Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged between the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes."

Biology

SB5. Obtain, evaluate, and communicate information to assess the interdependence of all organisms on one another and their environment.

c. Construct an argument to predict the impact of environmental change on the stability of an ecosystem.

QUESTION

Is this referring to succession?

RESPONSE

Yes, but not only succession. The standard refers to arguments that describe how changes caused by an event e.g., a forest fire, flooding, a draught, affect the environment and move it

away from a state of equilibrium and the consequences of these changes to the organisms that live on that ecosystem. It also refers to the idea of making predictions on how a possible change in the ecosystem will produce specific changes in an environment based on some type of evidence. Yes, this is the idea of succession since the expectation is to describe how an ecosystem changes overtime as a result of either catastrophic events; primary succession, or changes or disturbances in the communities that existed in a particular area; secondary succession

Biology

SB6. Obtain, evaluate, and communicate information to assess the theory of evolution.

a. Construct an explanation of how new understandings of Earth's history, the emergence of new species from pre-existing species, and our understanding of genetics have influenced our understanding of biology.

QUESTION

Do students need to know details about Earth's geologic history?

RESPONSE

Specific details of earth's history would be better suited for another science class, but a student understanding of multiple forms of evidence, both from the fossil record and genetics, as it relates to evolution is sufficient. Advancements in molecular tools have progressed understandings of biology. The idea is to construct causal relationships between geological events and the emergence of new species or the disappearance of a species. In addition, there is an expectation that the understanding of how the changes caused by these events created the conditions necessary to drive adaptations and the evolution of new species overtime.

Per *A Framework for K-12 Science Education (page 163):*
"Genetic information, like the fossil record, also provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence."

SB6. Obtain, evaluate, and communicate information to assess the theory of evolution.

d. Develop and use mathematical models to support explanations of how undirected genetic changes in natural selection and genetic drift have led to changes in populations of organisms.
(*Clarification statement:* Element is intended to focus on basic statistical and graphic analysis. Hardy Weinberg would be an optional application to address this element.)

QUESTION

Besides Hardy-Weinberg are there other mathematical models?

RESPONSE

The word "optional" here means Hardy-Weinberg is not required. The science practice of developing and using mathematical models for this explanation could include data, simulations, tables, and graphs to support the explanation. This is not limited to accepted

principles, such as Hardy Weinberg. For example, graphs would constitute mathematical models that show genetic drift.

Chemistry
SC2. Obtain, evaluate, and communicate information about the chemical and physical properties of matter resulting from the ability of atoms to form bonds. d. Develop and use models to evaluate bonding configurations from nonpolar covalent to ionic bonding. (*Clarification statement:* VSEPR theory is not addressed in this element.)
QUESTION In the chemistry standard one of the clarification statements say VSEPR theory is not addressed. How can you cover covalent to ionic ... polar to non-polar ... without VSEPR?
RESPONSE With this standard, students are not expected to evaluate whole molecules on the basis of polarity using molecular shapes. The focus is on individual bonds and simple molecules and compounds, not complex. Students should be developing models of different bond types. When molecular shape does impact molecule polarity, perhaps students should be given the shape or structure, and not have to determine the shape using VSEPR. Students should be considering electron arrangement as well as chemical properties as they develop models. Depending on your students, this could be addressed but it is not required.

Environmental Science
SEVI. Obtain, evaluate and communicate information to investigate the flow of energy and cycling of matter within an ecosystem. d. Evaluate claims, evidence and reasoning of the relationship between the physical factors and organismal adaptation within terrestrial biomes. e. Plan and carry out an investigation of how chemical and physical properties impact aquatic biomes in Georgia (*Clarification statement*: Consider the diverse aquatic ecosystems across the state such as streams, ponds, coastline, estuaries, and lakes.)
QUESTIONS We need clarification of standard 1d in relation to standard 1e on the environmental science standards. For instance, 1e is very focused on the aquatic ecosystems of Georgia. Is 1d referencing Georgia terrestrial ecosystems? The standards also have the aquatic ecosystems labeled as aquatic biomes. Are we missing something here? One of the things that has us confused is are we still teaching terrestrial biomes of the world (rainforest, grasslands, tundra, etc) or is it just the mountains, piedmonts, coastal plains, swamps and marshes, etc. of Georgia?
RESPONSE The standard does not limit you to Georgia; it is about any/all terrestrial biomes. The writers of this standard were working with the broad scientific thinking of biomes as being made up of many ecosystems…like an aquatic marine biome can contain a coral reef ecosystem. So like forest, grasslands, desert and tundra and then marine and freshwater. From the grade band end points found in *A Framework for K-12 Science* (p.152), the idea here is how do matter and energy move through an ecosystem, not list all the terrestrial biomes. Perhaps let students divide up into groups and do a particular one and then have groups share with the whole class so they end up with some understanding of them all but more importantly understand the flow of matter and energy through the ecosystem. The focus is not on memorizing all biome types but understanding relationships and adaptations.

Physical Science

SPS2. Obtain, evaluate, and communicate information to explain how atoms bond to form stable compounds.

c. Use the International Union of Pure and Applied Chemistry (IUPAC) nomenclature for translating between chemical names and chemical formulas.
(*Clarification statement:* Limited to binary covalent and binary ionic, containing main group elements, compounds but excludes polyatomic ions.)

QUESTION

Are transition metals considered "main group elements"? Or it implies we would solely consider alkali, alkaline earth, carbon group, etc.?

RESPONSE

No, the Representative Elements are those elements within groups 1 and 2, and groups 13-18 of the Periodic Table.

Physical Science

SPS4. Obtain, evaluate, and communicate information to explain the changes in nuclear structure as a result of fission, fusion and radioactive decay.

a. Develop a model that illustrates how the nucleus changes as a result of fission and fusion.

b. Use mathematics and computational thinking to explain the process of half-life as it relates to radioactive decay.
(*Clarification statement:* Limited to calculations that include whole half-lives.)

c. Construct arguments based on evidence about the applications, benefits, and problems of nuclear energy as an alternative energy source.

QUESTION

How deep do teachers need to cover alpha, beta and gamma decay? Do they need to include them in the calculations?

RESPONSE

The standard focuses in three practices, developing a model, using mathematical and computational thinking, and constructing arguments. The question seems to relate to the first two elements.

For SPS4a the evidence of learning is about students constructing models that can be used to show their understanding of what happens when a fusion or a fission process occurs. These models can take different forms from the students using a nuclear equation to show the change in the original nucleus as a result of either one of these two processes to drawings showing these changes. In either case, the model should show the understanding that the total number of protons and neutrons remains the same. Note that the standard does not address the processes of alpha, beta, and gamma decay. The understanding of these processes as they relate to fission is left for the physics course.

Physical Science
SPS7. Obtain, evaluate, and communicate information to explain transformations and flow of energy within a system. a. Construct explanations for energy transformations within a system. (*Clarification statement:* Types of energy to be addressed include chemical, mechanical, electromagnetic, light, sound, thermal, electrical, and nuclear.)
QUESTION This standard's clarification statement lists "electromagnetic, light" as two forms of energy that are to be included. Electromagnetic IS light. Is this supposed to be electrical energy? Or do we just need to make certain students know both terms?
RESPONSE Actually, light is considered twice in there. Light is a form of electromagnetic energy and it is also generated by an electric current. Think of it in this way; when you have a source of radiation, e.g. the sun or red-hot iron, light, meaning that part of the spectrum that we can see, is emitted. Therefore, you have an energy transformation there. Light as energy is also the result of the glowing of wire in the light bulb caused by electric current passing through. In this case, light is considered as electrically caused. The focus of the standard is not on terminology, but on students constructing explanations for various energy transformations.
SPS7. Obtain, evaluate, and communicate information to explain transformations and flow of energy within a system. b. Analyze and interpret specific heat data to justify the selection of a material for a practical application (e.g., insulators and cooking vessels).
QUESTION Are students still expected to calculate specific heat using the equation, $Q = mc\Delta T$? In the GPS, it was clear the students should use the equation. In the GSE, it seems as though students will be presented with the specific heat of materials and a calculation may not be necessary.
RESPONSE Just knowing how to complete the formula is not what the intent of the standard is. Students are assessed on both the practice and the core idea and will be asked to analyze and interpret specific heat data and apply that in a practical sense. In the classroom, students should have an opportunity to analyze and interpret specific heat data that they collected. Part of the analysis of interpreting specific heat data goes to the understanding on how heat is absorbed by a particular material, how much could be absorbed before the temperature starts to change, etc. All this understanding may require students to calculate heat at some point.

Physics

SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions.

e. Plan and carry out investigations to clarify the relationship between electric currents and magnetic fields.
(*Clarification statement:* This includes coils and their importance in the design of motors and generators.)

QUESTIONS

1. Should our investigation give only a qualitative description (direction) of force acting on wire with current in magnetic field or we can discuss equation of the force $F = ILB \sin \theta$
2. Can we talk about force acting on charged particle moving in magnetic field? This force is fundamental and is responsible for force acting on wire.

RESPONSE

The standard is constructed to provide a qualitative description of the interactions that result from the presence of magnetic and electric fields.
The grade band endpoint (at the end of high school) described in *A Framework for K-12 Science Education* ***(page 117)*** sets the following expected understandings

a. Electric and magnetic forces are different aspects of a single electromagnetic interaction.
b. Electric and magnetic forces can be attractive or repulsive, depending on the relative sign of the electric charges involved, the direction of the current flow, and the orientation of the magnets.
c. The forces' magnitudes depend on the magnitudes depend on the magnitudes of the charges, currents, and magnetic strengths as well as on the distances between the interacting objects.
d. At the atomic scale the attraction and repulsion of electric charges explain the structure, properties, and transformations of matter and the contact forces between objects
e. Coulomb's law provides the mathematical model to describe and predict the effects of electrostatic forces between distance objects.

From these expectations, there is not a need to provide the students with the mathematical representation of the magnetic force on a wire carrying a current caused by an external magnetic field. As stated in part b above the important understanding is for the investigation to provide students with the evidence needed to arrive to relationships listed there.
There may not be much benefit gained by providing the students with an equation that they do not know how to derive.
As for the second question. That is the point of the investigation, to discover or understand the effect that the presence of a magnetic field has on a charged particle.