

The Use of Authentic Context to Foster Independent Learning in Science

by

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## Table of Contents

Chapter 1: Introduction.....	3
Chapter 2: Literature Review	
Reasons for Change.....	6
Reasons for Change /Preparing Students for the Future.....	8
Reasons for Change / The Lack of Student Engagement.....	10
The Shift to Literacy in the Science Classroom.....	12
The Need for Contextual Learning.....	14
Argumentation Learning.....	16
Strategies for Improving Science.....	17
Chapter 3: Application.....	18
Chapter 4: Conclusion.....	90
References.....	92

## **Chapter 1: Introduction**

Teachers have the immense responsibility of preparing students for their future, whether it is college or a vocation. It is the goal of most teachers to provide their students with independent learning skills so that they are equipped to find answers to the questions that will arise during the course of their journey through school life and/or career. Developing independent learners is our noble goal. The Common Core Standards state that building the skills those students will need for college, career, participation in society and personal health and happiness (National Governors Association Center for Best Practices, 2010). It is suggested that students need to develop and/or improve skills in dealing with contemporary democratic societies; lay citizens need to understand the nature of scientific knowledge and practice, in order to participate effectively in policy decisions, and to interpret the meaning of new scientific claims which affect their lives (Sandoval, 2005).

This paper will be describing several of these methods to foster skills such as independence. It will also describe how the skills help students to better comprehend and find answers to their questions, mostly in the science subject area, which is my area of certification. An important task of science education is to make science more relevant to students, more easily learned and remembered, and more reflective of the actual practice of science. In most present day classrooms students aren't independent learners and science classes aren't connected to authentic contexts. This paper will discuss ways to make science easier to learn using

authentic literacy which emphasizes student responsibility for retrieving information. This paper will discuss methods for engaging students in non-fiction reading and writing by establishing the context for learning and providing students with the opportunity to use evidence to make valid arguments.

Traditionally, textbooks and workbooks are used as the main learning tools in most standards driven science classes. In my own school, the seventh grade workbooks that students are currently using are a very dry and boring read. Through this thesis paper the plan is to give them contextual relevant reading to stimulate their interest in science. All the necessary science standard material will be included but it will be set in a context that students will find more relevant to their daily lives and not just science fact after science fact, which is much more engaging than the traditional fact based text (Hand et al., 1999).

Scholars have suggested that a human's ability to conceptualize the world is connected to the medium of expression common to their culture (Sapir, 1949). A recurring theme throughout the research was finding text or projects that were non-traditional text and were also something that peaked students' interests. Students need to learn through a "medium" that they encounter in life and therefore non-traditional texts were selected that the students may encounter in their lives. Many of the articles focused on scientific literacy, as described by the American Association of the Advancement of Science, a series of benchmarks of what students should know and be able to do at the end of grades 2, 5, 8 and 12 (AAAS, 1993). The science education research literature has a lot to offer in the areas of using authentic

context to foster independent learning in science. Student interests range from sports to reading and writing as each of these interests can be used as a context for learning science. Sports have been used to introduce Physics in the science classroom and reading and writing are a good way of expressing the importance of keeping a journal and looking for clues in forensics.

In addition to literature related to context-based learning, much of the research was on argumentative writing and discussion; which was another form of science instruction where students were encouraged to defend their views using critical thinking skills. Making science more relevant to students and their daily lives may be the motivation they need to become independent learners which would be a great reward for any teacher in and of itself. Identifying the appealing elements of these alternative texts could assist teachers in designing instructional activities that are relevant to and motivating for today's students (Alvermann, Moon, & Hagood, 1999).

## **Chapter 2: Literature Review**

### **Reasons for Change**

There is a quick disconnect with most students when it comes to science. They have been used to fiction literature in elementary school and then, all of a sudden, they have to dig through less engaging non-fiction, technical and scientific texts for specific answers to specific questions from middle school science on through high school and college. Science texts often pose special challenges for inexperienced and struggling readers, particularly when those students are transitioning from the elementary to middle grades. One way to possibly include both fiction and non-fiction material while keeping both interesting would be to include reading trade journals for those interested in learning about possible careers in the scientific arena.

Students may have trouble understanding how science information is displayed and organized (such as in figures, diagrams, graphs, and drawings); grapple with technical or specialized vocabulary to convey scientific ideas and concepts; and have difficulty understanding the syntactic structures used to express complex scientific processes and concepts. Helping students move among representation types, connecting to real-world examples and noting how different formats convey the same information, is beneficial for student learning (Sullivan, 2006).

Science education plays a very important role in broadening students' world outlook. An important task of science education is making science more relevant to students, more easily learned and remembered, and more reflective of the actual practice of science. Hence, the importance of establishing context cannot be overstated as it is crucial and may be the key piece of independent learning.

Science teachers are not trained in literacy. The typical science methods course in a teacher preparation program is built upon three main components: (a) supporting in-depth science content learning of selected topics especially relevant to elementary teaching, including understanding of how scientists do science; (b) engaging in model inquiry-based lessons that emphasize big ideas in science; and (c) providing opportunities to apply new understandings and practices to classroom teaching (Zemba-Saul, 2009).

### **Preparing Students for the Future**

Why do we need to change? To better prepare students for the very real conditions they are going to face in the future. Research states how important it is for students to know how to get needed information from their reading. Document Based Questions or DBQs as they are known are here to stay. They are not only found on the New York State Regents exams, but all through middle school, high school, and college as teachers have to decipher several DBQs on the three New York State teacher certification exams. Since this is a weak area for many students, if it can be made any easier for them now, it will help them in their future.

The science standards documents (NRC, 1996, 2000) emphasize scientific explanations as an *essential feature, a fundamental ability, and a fundamental*

*understanding* of scientific inquiry. In the words of the NRC (2000) report, students should: (a) “give priority to *evidence*, which allows them to develop and evaluate explanations that address scientifically oriented questions” (p. 25), (b) “formulate *explanations* from evidence to address scientifically oriented questions” (p. 25), (c) “formulate and revise scientific explanations and models using logic and evidence” (p. 19), and (d) have a clear understanding that “scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models and theories” (p. 20). Scientific inquiry, then, is fundamentally about acquiring relevant data, transforming data first into evidence, and then into explanations, that address particular scientifically oriented questions (Duschl, 2003; Sandoval & Reiser, 2004).

The educational powers, state and local curriculum writers as they are beginning to implement more non-fiction DBQ type learning at the elementary level to prepare students for middle school. In today’s world where science is playing a major role in magazines and newspapers concerning environmental issues such as global warming, acid rain, and nuclear waste, the ability to comprehend various types of text will be necessary for students the rest of their lives. Even if the students plan on a civil service career instead of going to college, these can be found on the civil service exams as well. As Educators we must ask ourselves if we are meeting the needs of today’s students. The science world is adapting to our ever-changing society; is the methodology and philosophy of our educational system keeping up? How are we preparing our students to work in this new world?

## **The Lack of Student Engagement**

Science textbooks rarely provide a sense of purpose, take into account students' ideas, engage students with relevant phenomena develop fundamental scientific ideas and distinguish them from factual details, or promote student thinking. Consequently, teachers should not rely on the textbook as the primary source of knowledge in the course, nor should such materials dictate the pedagogy that teachers use (Olson & Mokhtari, 2010).

The recurring theme going throughout science education research was to make the learning interesting and relevant, especially in science since the subject matter itself can seem so distant from their daily lives. Unfortunately, most science courses are content-driven and reinforce students' negative view that science is a collection of facts unrelated to their world. For non-majors and members from traditionally underrepresented groups, experiencing science in a teacher directed manner particularly diminished their interest (Cuevas, et al., 2005; Lee, et. al., 2004).

Linking the material to students' lives is not generally promoted in the courses, although an emerging body of research indicates that students who are intrinsically interested in an activity (or topic) are more likely to see challenging tasks as worthwhile, think more creatively, exert effort and learn at a higher conceptual level than students who are not intrinsically interested (Kitchen, et al., 2007, Long et al., 2007). Seeds of Science: Roots of Reading implemented an experimental hands-on curriculum, which blended science and literacy (Gyrod & Twyman, 2009).

In this study, Seeds was pitted against another hands-on inquiry based curriculum entitled Gems (Great Expectations in Math and Science) that did not include the literacy piece. The categories on the pretest were affect, interest, efficacy and identity relating to science. The posttest results showed that the Seeds experimental class exceeded the GEMS comparison class by 5 points for tests of conceptual understanding. Interviews showed that there were no significant differences. Reading during science was encouraged in both classes but the GEMS class focused on fictional storytelling as one student described how raindrops formed. The Seeds class students were encouraged to review the ideas of a scientist as illustrated by the following exchange between the teacher and a student:

Teacher:      What are the main ideas about decomposing that these scientists are trying to tell us?

Student:      I found one book that says earthworms squirt out mucus when they're scared and another that says they use mucus to slide through the dirt. Which one is right?

The hands on work of the GEMS group showed more growth in two of the four categories, interest and affect, but the Seeds group scored significantly higher in the other two; identity and efficacy. Ratings of students' understanding of NOS were statistically significant for the experimental group. It is important to note that this is an elementary level program and a larger sample size should be used in the future (Gyrod & Twyman, 2009).

## **The Shift to Literacy in the Science Classroom**

Divergent arguments abound concerning scientific learning and the best instructional methods. The arguments range from integrating or infusing reading or the more hands on approach of inquiry learning. Until recently, the focus of science education has largely been on science as a practical subject that involves hands-on experiments and field-based observations (Wellington & Osborne, 2001). This is understandable, because science is in part an empirical subject. However, as Michael Halliday (1998) has suggested, science is also a semiotic subject involving the use of language. This is especially true in regards to written language, which we call 'text'. Norris and Phillips (2003), for example, argued that science is in part constituted by texts and that science literacy comprises not just knowledge of the substantive content of science, but 'the concepts, skills, understandings, and values generalizable to all reading' (p. 235). According to Hand, Alvermann, Gee, Guzzetti, Norris, and Phillips:

Without text and without reading, the social practices that make science possible could not be engaged: recording and preserving data; encoding accepted science for anybody's use; reviewing of ideas by scientists anywhere; reexamining ideas at any point in time; connecting ideas to those developed previously (intertextuality); communicating ideas between those who have not met or lived at the same time; encoding variant positions; and focusing attention on a text for the purpose of interpretation, prediction, explanation, or test. (2003, p. 612)

As with literacy, science can be viewed as a discursive process requiring the making of meaning through language, text, signs and symbols (Lemke, 1990). In short, reading can support constructive learning, inquiry, and problem-solving (Glynn & Muth, 1994).

One of the articles researched gauged the effect that reading science trade books had on a science class. The reading infusion consisted of two components: one reading strategy lesson for 15-20 min per week; and a home reading program that encouraged students to read and respond to one quality science trade book per week (Fang, Lamme, Pringle, Patrick, Sanders, Zmach, Charbonnet, & Henkel, 2008). Students took one book home for the week and discussed and shared with family members. When they returned the book, they discussed their responses to the books with their teacher before checking out a new book for the following week. A total of 200 books were rotated mid-way through the semester to provide selection variety for each of the classes.

The testing that was used on students that received the reading infusion program and students that didn't showed that the inquiry-based science curriculum with the reading infusion is more effective in improving science literacy than the curriculum without. Students were required to bring home trade journals and discuss them with family members. In addition, parents responded positively to the home science reading program as demonstrated by some of the following quotes: "When he brought home the book on inventions and their inventors, we talked about how some of the inventors weren't necessarily the best students, but they kept persevering to solve the problem." and "We enjoyed the book's pictures and the length of the stories" (Fang et al., 2008).

Research indicates that the integrated reading approach supports student learning and also engages students by providing choice. An important task of science education is to make science more relevant to students, easier to learn and

remember. The research indicates that this is more reflective of the actual practice of science.

### **The Need for Contextual Learning**

Inherently, scientific literacy has meaning for all citizens and directly impacts their concerns and needs. Therefore, the Science-Technology-Society (STS) movement that originated in the 1970s has taken a prominent position in the debate concerning scientific literacy (e.g., Aikenhead, 1994, 2002; Bingle & Gaskell, 1994; Gaskell, 1982; Solomon, 1993). According to this movement, students should engage in issues pertaining to the impact of science on everyday life and act responsibly in response to such issues, eventually with the ultimate aim of social action (Ramsey, 1989).

The creation of evidence-based arguments, defined as claims supported by evidence with premises, is central to the science inquiry process and the evaluation of scientific claims (Driver et al. 1998; Perelman and Olbrechts-Tyteca 1958). One instructional approach that engages students in argumentation is Problem-based Learning (PBL; Gallagher et al. 1992; Hmelo-Silver 2004). In problem-based learning, students in small groups are presented with an ill-structured problem, or a problem with multiple solutions and solution paths. After defining the problem, students need to determine and gather needed information and develop and defend a possible solution (Barrows 1985; Hmelo-Silver 2004).

Instructional methods like STS and PBL both serve to engage and motivate students by making science more relevant to their daily lives and issues that will

arise eventually whether it is in school or career choice. Using authentic issues in the classroom also allows an instructor to foster the students' skills of critical analysis and life-long learning that they need to deal with the changing nature of science in society. Providing students with the tools necessary to critically evaluate and make decisions about the future scientific issues they will face is central to scientific literacy education. In one of the journals researched, entitled **Portraits of middle school students constructing evidence-based arguments during problem-based learning: the impact of computer based scaffolds**, scaffolding was used, via a computer program called Connection Log, by students to support their argumentation (Belland, 2009). This system ensured that students had to confer with fellow students via the connection log to gather all the information necessary to back up their arguments or claims.

The scaffolds were organized in six stages; define problem, determine needed information, find needed information, organize information, develop claim and link evidence to claim. To use the system, students register as groups, log in, complete tasks, save their information to the database, and move on to the next task. Ironically, the individual responsibility that each member brought to the exercise made them realize that each had their specific responsibility to the success of their group. Because of the nature of middle school students, the connection log helped them to get and stay organized, manage group work, and stay on track. This exercise will help students to become independent learners as well as learn to collaborate in groups. This is a skill necessary for college and career readiness.

## **Argumentation Learning**

The improvement of middle school students' argumentation skills may help them prepare for success after high school, as 8<sup>th</sup> grade academic performance is the strongest predictor of college and career readiness (American College Testing 2008). Finding authentic text to back up scientific claims is a key step in argumentation and it is also part of independent learning which is the goal for many students. Through the creation of arguments, students communicate and justify their understanding to themselves, each other, teachers, and others. Argumentation is situated as a central element in the learning of science as it makes "student scientific thinking and reasoning visible to enable formative assessment by teachers or instructors" (Osborne, Erduran, & Simon, 2004, p. 995).

But argumentative talk, either dialectical or dialogical cannot be easily sustained in science. In a series of experiments, Asterhan and Schwarz (2007, 2009) checked whether dyads of students could learn the concept of evolution after being invited to discuss the solution of a problem on the issue. Asterhan and Schwarz showed that asking students to comply with norms of critical reasoning in their argumentation was not enough to yield dialectical talk, but that showing evidence before discussion and prompting to argumentative talk during discussion led to dialectical talk and conceptual change after interaction.

The research article entitled **A Learning Progression for Scientific Argumentation: Understanding Student Work and Designing Supportive Instructional Contexts** explored the differences of elementary, middle school and high school students and their approaches to argumentation (Berland & McNeill,

2010). The study showed that argumentation based on scientific data and analysis is a successful tool for students in grades 5 through 12. The instructional context may also be used as a tool to support students in argumentation in new content areas and to increase the complexity of their written arguments, which may be weaker than their oral arguments.

The skill of argumentation is a valued skill in the workplace and education that can be a useful tool for any science student or employee that needs to defend their ideas either in the classroom or the workplace. By placing students in the authentic context of argumentation, the teacher is preparing them for a future of independent learning that can only help them succeed in school and/or the workplace.

### **Strategies for Improving Science**

The literature establishes the need to improve science instruction in order to make it more interesting for students to learn and provide various methods of instruction. Context-based learning, puts the students in an environment usually outside the classroom but suitable for learning. Argumentation helps students support their findings. The literature shows that student learning improves by using these methods.

The next logical step points to text dependent learning. Students are more apt to be interested in non-traditional text, such as a magazine article about a sport or an athlete which we can somehow relate to science. By changing or mixing the genre, to a topic that is more relative to the students' lives outside school, one can

capture the students' interest and develop some scientific questioning in relation to the topic and/or content of the article.

The literature supports text dependent learning. A unifying theme is to capture the interest of students by relating to their lives outside of school. Recent research provides some support for reform recommendations. For instance, research shows that teachers incorporate recommended reforms into their instruction, student learning improves (Geier et al. 2008; White and Frederiksen 1998; Williams and Linn 2002), and student interest, engagement and motivation in science is enhanced (Engle and Conant 2002; Mistler-Jackson and Songer 2000; O'Neill and Polman 2004). The current movement to support science learning with non-fiction literature such as trade journals is an example of the research-based reform.

The purpose of this thesis project is to make learning science more interesting for students through story based (case based/problem based) learning. Each lesson will contain a story which will explain learning standards so that students will accomplish the intended outcomes. I want to make learning science more interesting for my students as do most teachers. The first project I'd like to tackle, if my proposal gets accepted, is the 7<sup>th</sup> grade workbook Measuring Up, which is a very dry read. I'd like to take each lesson and create a story containing the learning and make it an interesting read for my students. I think I know them quite well now, it is my fourth year in this setting, and I believe that creating more interesting reading will capture their attention and make learning science enjoyable as well as educational.

### **Chapter 3: Application**

What I learned in theory from my research was to make the learning more relevant to students' lives outside of school. By creating fictional stories for each of the lessons I was able to surround the non-fictional content with storylines and characters that students could relate to. Once drawn in by the fictional scenarios, my hope was that the scientific content would be easier for students to extract from the reading to answer questions that check for understanding.

My impetus for this project was to identify what could I work on that would most help the students I teach and be useful as a tool for other teachers to use as well. With much reflection on my day to day struggle with making content interesting for my students, I decided to make the seventh grade science lessons a more interesting source of non-fiction information. I took twenty lessons and created fictional situations that would draw students' interests in as they would be able to relate to the subjects in the storyline for each of the lessons.

The main difference between the way the textbook lesson presents its content and the way I wrote each lesson plan was all in the presentation. The questions in the textbook lesson that students need to answer are virtually no different than the questions after each of my lessons. The scenarios that I surrounded the content with are real world and contextual. The work required of students is straight forward and more user friendly so the students will have a much easier effort extracting answers to the questions. By engaging students in an interesting fictional story, the non-fictional scientific content doesn't seem as alien to their daily lives.

The existing textbook lessons make it hard for students to relate to all the scientific content because they don't relate to the scientific instruments and content described by the textbook writers. Through creative writing I was able to fit non-fiction scientific content within a fictional and I hope interesting setting for the students so that they learn the necessary material without realizing or feeling like it was a cumbersome experience.

## Lesson 1

### Science, Inquiry, and Systems

#### Focus on the NYS Learning Standards

**S1.1a** Formulate questions about natural phenomena.

**S1.2c** Differentiate among observations, inferences, predictions, and explanations.

#### Understand how scientists learn about the world and how science constantly builds on existing knowledge.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Tim and Steve were arguing about which ball would bounce higher, a lacrosse ball or a golf ball. Tim suggested that they do a scientific investigation. Steve asked what can be found out by doing a scientific investigation. “Well” Tim said “A question can be answered by careful observation, like which ball would bounce higher. Steve asked if he could predict which ball would bounce higher. Tim answered that it wouldn’t be based on scientific investigations, so it wouldn’t be a confident prediction. So Steve asked, “When you can confidently make a prediction based on scientific investigation?” To which Tim answered “If after a certain investigation is done, you and other people observe the same results, you can predict that the same thing will happen if you try the same investigation.

Steve replied, “It seems like there’s a system to everything.” Tim informed that there are two types of systems that he’s aware of; engineering and social. Steve thought that he knew but he asked Tim if he could describe the similarities and differences between engineering and social systems. Tim stated that both engineering and social systems are created by human beings. Engineering systems often include machinery, such as a dam or nuclear power plant. Social systems involve the organization of human beings in an activity, such as in a school or a hospital.

Steve suddenly understood and told Tim that he knows what all systems have in common. Tim asked him to elaborate, to which he replied that all systems have parts that can be connected in some way. Tim asked if he could give him three examples of each. He told Steve that dynamic systems include systems that involve force and motion. Steve, feeling very confident, said “Oh, you mean the cardiovascular system, or solar system, an assembly line, power plant, and an automobile. Impressed that he had come up with more than three, Steve continued on with more examples of organizational systems such as the periodic table, the government system, and a school system.

Tim asked Steve if he knew that some systems have more than one classification. He went on to say that a hydroelectric dam is an example of an engineering system because moving water moves the turbines. It is also a dynamic system. Although the water in the dam is natural,, the dam was designed by people to make electricity. Boy, Steve said, we really got off the subject by talking about systems, didn't we? Tim replied "Not really, we were talking about making predictions and systems help scientists make predictions. Systems allow scientists to connect objects or processes that might not seem connected. This allows them to make better predictions, because they have more information.

**DIRECTIONS** For each question, write your answer in the space provided

1. What kind of questions can be tested by a scientific investigation?

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2. When can you confidently make a prediction based on scientific investigations?

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3. Describe the similarities and differences between engineering systems and social systems.

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4. What do all systems have in common?

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5. What are three examples of dynamic systems? What are three examples of organizational systems?

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6. What kind of system is a hydroelectric dam? Explain your reasoning.

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7. How do systems help scientists make predictions?

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8. Apply what you have learned from this scenario.

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## Lesson 2

### Scientific Processes

#### Focus on the NYS Learning Standards

**S1.1a** Formulate questions about natural phenomena.

**S2.2d** Identify independent variables (manipulated), dependent variables (responding), and constants in a simple controlled experiment.

**S3.2c** Evaluate the original hypothesis in light of the data.

#### Learn the steps and skills involved in planning investigations in a research setting.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

As they were walking home from school, Mike asked Dave where he finds information for homework assignments and such. Dave said that there is actually more than one source for research. He said that a library's reference section is a good place to start because it contains an encyclopedia, periodicals, and web sites ending in .edu and .org.

Mike said that he wouldn't know where to start. Dave answered that the first step in planning an investigation is observing and formulating a question. Mike asked about his hypothesis, "does it have to be correct. And if it's wrong, is it a bad hypothesis?" Dave answered that if it is testable; it is a good hypothesis, whether it is wrong or right.

Mike said that he knows that there are two variables but he isn't sure about the differences. He told Dave that he thought that they were called dependent and independent. Dave told Mike that the dependent variable changes as result of the independent variable. And that the independent variable is changed on purpose to see its effect on the dependent variable.

Mike asked Dave, "Why it is a good idea to have only one independent variable?" Dave answered, "That way you know that the changes you observe are due to the variable you are testing and no other variable." Dave believed Michael needed an example, so he told him about a scientist named Ivan Pavlov. He asked Mike if he knew what observations led Pavlov to ask scientific questions. Michael did not have a clue. Dave told him that he noticed his dogs drooling when he brought them food and when they saw someone coming wearing a lab coat.

Dave asked Mike what he thought may have been Pavlov's hypothesis? When he noticed Mike struggling for a response, he said possibly animals can train their bodies to respond to certain signals. Dave asked Mike what he thought was the independent variable in his experiment. Mike knew the answer to this one. He said different types of signals, for example, people wearing white coats or ringing the bell.

Therefore, Dave asked Mike, what was the dependent variable? To which Mike replied, the dogs' reaction. What do you think were the control variables? Dave asked Mike. Mike responded, "The animals, the type of food, and the amount of food." Dave gave Mike some key words he might research to learn more about Pavlov's experiments. The words were Pavlov, phobia, dogs drooling and operant conditioning.

**DIRECTIONS** For each question, write your answer in the space provided

1. Name three good sources for research information.

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2. What is the first step in planning an investigation?

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3. If a hypothesis is wrong, is it a bad hypothesis? Explain.

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4. What is the difference between a dependent and independent variable?

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5. Why is it a good idea to have only one independent variable?

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6. What observations led Pavlov to ask scientific questions?

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7. What may have been Pavlov's hypothesis?

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8. What was the independent variable in his experiment?

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9. What was the dependent variable?

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10. What were the control variables?

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11. Apply what you have learned from this scenario.

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**12.** What key words might you research to learn more about Pavlov's experiments?

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## Lesson 3

### Safety in Science

#### Focus on the NYS Learning Standards

**S2.2a** Include appropriate safety procedures.

**ICT 6.1** Determine the criteria and constraints and make trade-offs to determine the best decision.

**To stay safe during investigations, use the correct safety equipment and practices.**

**Technological solutions solve human needs if done in a safe and ethical manner.**

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Felix is very neat, while his friend Oscar is just the opposite; very messy. Oscar would like to use Felix's lab space but before Felix lets Oscar use it, he asks him a series of questions. Felix starts off by asking Oscar why some students might try to hide an accident in a lab and what can result if they do? Oscar gave a very good response; he said the students might be embarrassed or concerned about being blamed for the accident. However, they might be cut or burned if they try to clean up an accident on their own.

Felix is impressed with Oscar's answer and proposes the following scenario: You have found a bottle filled with a pinkish liquid on your lab table. What is the safest way to find out what is in the bottle? Oscar replies that he would not taste, smell, or touch it, but, instead, would ask the teacher what was in it. Felix gives Oscar another scenario since he is answering every question correctly. He tells Oscar; you decide to pour leftover acid down the drain after a science experiment, why is this not ethical behavior? That's easy, Oscar states, the acids could pollute the public's water supplies.

Felix asked Oscar what are some safety concerns you should be thinking about when you pour into a test tube? Oscar started to brainstorm; not dropping either test tube; not spilling the chemicals; remembering to pull the test tubes away from you and others; to pour slowly and what might happen when the chemicals mix. Oscar asked Felix what kind of safety equipment you should be wearing. Felix answered goggles, apron and gloves. Oscar asked in addition to using safety equipment, what actions would help you avoid accidents as you carry out the investigation? Felix answered: Carry out the investigation steps carefully and in order, be sure you are mixing the right chemicals in the right way, measure accurately, and concentrate so as to not become distracted by classmates.

Felix asked Oscar “You notice that one of the test tubes you’re using is cracked, what should you do? Oscar answered “Pour the chemical into another test tube before it starts leaking, and tell the teacher about the cracked tube. Felix asked Oscar “How should you dispose of the chemicals after the investigation is over? Oscar said “That’s easy; follow your teacher’s directions.” Finally, Felix asked Oscar, “What should you do after the investigation is over and all the equipment is put away?” Oscar answered “wash your hands with soap and hot water.”

**DIRECTIONS** For each question, write your answer in the space provided

1. Why might some students try to hide an accident in a lab? What can result?

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2. You have found a bottle filled with a pinkish liquid on your lab table. What is the safest way to find out what is in the bottle?

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3. You decide to pour leftover acid down the drain after a science experiment. Why is this not ethical behavior?

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4. What are some safety concerns you should be thinking about as you pour?

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5. What kinds of safety equipment should you be wearing?

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6. In addition to using safety equipment, what actions would help you avoid accidents as you carry out the investigation?

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7. You notice that one of the test tubes you're using is cracked. What should you do?

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8. How should you dispose of the chemicals after the investigation is over?

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9. What should you do after the investigation is over and all the equipment is put away?

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10. Apply what you have learned from this scenario.

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## Lesson 4

### Measurement and Tools

#### Focus on the NYS Learning Standards

- M1.1c** Apply mathematical equations to describe relationships among variables in the natural world.
- M3.1a** Use appropriate scientific tools to solve problems about the natural world.
- IS 2.1b** Identify and explain sources of error in a data collection.

#### **Demonstrate an understanding of measurements taken during scientific investigations, and of the tools used to quantify them.**

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Simon's favorite subject was science, and his favorite science teacher was Mr. Poindexter. Mr. Poindexter let Simon stay after school and help him set up for the next day's labs and experiments. Simon asked Mr. Poindexter "Why is a standard system of measurement needed in science? Mr. Poindexter explained "So scientists worldwide can compare and understand data."

Something that always bugged Simon was when a small object partially sinks in water. Simon asked Mr. Poindexter "Use the displacement technique to find the small object's volume. Can you explain this to me?" "No, Mr. Poindexter answered, "in order to find the volume, the solid object has to sink completely." "Let me ask you a question Simon, what two measurements must be taken before density can be found?" "That's easy, Simon replied, "mass and volume."

Mr. Poindexter gave Simon a math problem; He said "A graduated cylinder contains 8 mL of water. After placing a rock in the cylinder, the water comes up to the 15 mL interval. What is the rock's volume? And Simon, please show your work." "That's simple," Simon answered and wrote down:  $15 \text{ mL} - 8 \text{ mL} = 7 \text{ mL}$ . Mr. Poindexter said, "Therefore Simon, can you tell or explain why density is a ratio?" Simon said "Sure, density is a ratio because it tells you how much mass is packed in a unit volume."

"Let me give you another math problem," Mr. Poindexter responded, "an object has a mass of 40.0 kg, its volume is 25 cm<sup>3</sup>. What is its density? Simon, remember to use the correct units in your answer and show your work. Simon's work looked like this:

$$\begin{array}{r} 1.6 \\ 25 \overline{) 40.0} \\ - 25 \phantom{0} \\ \hline 150 \\ - 150 \\ \hline 0 \end{array}$$

$$40.0 \text{ kg} / 25 \text{ cm}^3 = 1.6 \text{ kg/cm}^3$$

Simon asked Mr. Poindexter “Something that has bugged me is what the difference is between mass and weight.” Mr. Poindexter said, “Mass is a measure of the amount of matter that a person or an object carries. Weight is a measure of the force of gravity as it acts on an object or person. The mass of an object is always the same but the weight depends on the force of gravity.” “One last test Simon, “Mr. Poindexter said, “Explain how to use a triple beam balance to find mass.” Simon said “First, set the mass equal to zero grams. Place the object on the pan, and slide the masses on the three arms until the weight is equally balanced on both the pan and the arms. When the pointer is centered, you have found the mass of the object. Add the masses on three arms, and that is the mass.”

**DIRECTIONS** For each question, write your answer in the space provided

1. Why is a standard system of measurement needed in science?

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2. A small object partially sinks in water. Can you use displacement technique to find its volume? Explain your answer.

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3. What two measurements must be taken before density can be found?

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4. A graduated cylinder contains 12 mL of water. After placing a rock in the cylinder, the water comes up to the 25mL interval. What is the rock's volume? Show your work.

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5. Explain why density is a ratio.

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6. An object has a mass of 40.0 kg; its volume is 25 cm<sup>3</sup>. What is its density? Use the correct units in your answer. Show your work.

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7. What is the difference between mass and weight?

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8. Explain how to use a triple beam balance to find mass.

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9. Apply what you have learned from this scenario.

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## Lesson 5

### Analyzing and Displaying Data

#### Focus on the NYS Learning Standards

- M1.1b** Identify relationships among variables including direct, indirect, cyclic, constant, identify non-related material.
- M2.1a** Interpolate and extrapolate from data.
- M2.1b** Quantify patterns and trends.

#### **Express relationships mathematically by using graphs, and interpret a graph to tell what kind of relationship is represented in the graph.**

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Dwayne and LeBron were keeping track of their basketball game statistics and were considering charting their data on a graph. LeBron asked Dwayne “When is it helpful to make a graph of a data set?” Dwayne replied “When you want to see the relationship between two variables.” LeBron asked “If a graph of a data set forms a curve, what kind of relationship is it?” Dwayne simply answered “Nonlinear.”

Dwayne began to quiz LeBron “What are three kinds of relationships that a graph can show?” LeBron replied “Linear, nonlinear and cyclic.” “Very good,” Dwayne responded, “now answer me this; what is extrapolation of data and what is interpolation of data?” LeBron was up to the task. “Extrapolation is when you estimate an unknown value based on known values by continuing a trend or pattern. Interpolation is when you estimate an unknown value between two known values by following a trend or pattern.”

Dwayne asked LeBron to look at a data table he had made of LeBron’s points scored during a game. In the first column was minutes played and in the second column were points scored. Each of the values in both columns got greater as you went down the column. Dwayne asked LeBron “What kind of relationship is there between minutes played and points scored, can you explain this trend?” LeBron answered “There is a direct relationship between minutes played and points scored.” Dwayne asked LeBron to complete a graph he had started with the data points from the table. Minutes were along the x-axis, points scored along the y-axis.

The graph of the line could be represented by  $Y = .75 X$ . Dwayne asked LeBron “What does the value .75 points/minute represent?” LeBron answered “It is the slope of the line.” Dwayne asked LeBron to “Explain if the relationship shown in the graph is linear?” “Some of the data points do not quite fit on the line. But, overall,” LeBron replied, “the data set fits on a line with a certain slope, so the relationship shown during the time that data were recorded is basically linear.” Dwayne had one last question for LeBron, “Suppose the game goes into overtime and you continue scoring at the same rate as before. How many more points would you score at the end of the five minute overtime period?” LeBron answered, “If I

kept scoring at the same rate, .75 points/minute, five minutes more would give me between 3-4 points.

**DIRECTIONS** For each question, write your answer in the space provided

1. When is it helpful to make a graph of a data set?

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2. If a graph of a data set forms a curve, what kind of relationship is it?

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3. What are three kinds of relationships that a graph can show?

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4. What is extrapolation of data? What is interpolation of data?

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5. What type of relationship is there between minutes and points scored? Explain.

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6. A graph of the line of points scored/minute could be represented by  $Y = .75X$ . What does the value .75 points scored/minute represent?

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7. Is the relationship between points scored and minutes played linear? Explain.

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8. Suppose the game goes into overtime, and the scoring rate stays the same as before. How many more points will have been scored by the end of the five minute overtime?

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9. Apply what you have learned from this scenario.

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## Lesson 6

### Models and Technology

#### Focus on the NYS Learning Standards

- ICT 2.1** Select an appropriate model to begin the search for answers or solutions to a question or problem.
- ICT 2.2** Use models to study processes that cannot be studied directly (e.g. when the real process is too slow, too fast, or too dangerous for direct observation).
- ICT 2.3** Demonstrate the effect varies of different models to represent the same thing and the same model to represent different things.

#### Scientists use models and symbols to understand why things work and how things happen.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Thelma and Louise did everything together. Now they were trying to decide on a science project that would be entered in the school science fair. Thelma wondered aloud “Why would scientists create models of atoms?” Louise answered back “Easy silly, to make these small particles easier to study and compare.” Thelma dug deeper “Why would scientists make a three-dimensional model of a heart, as well as an illustration with labels?” “Duh!” answered Louise “Scientists make a three-dimensional model of a heart to show all of the parts of the heart.”

Louise felt it was her turn to question Thelma “Mountains take a very long time to form. What is one reason to create a model of mountains forming?” Thelma actually gave two answers, “Most of this process happens underground where no one can see it. The process is too big and too long to see all at once.” Louise went on to show Thelma a model of a forest food chain and a model of an abandoned field transitioning into a forest and asked “Whose model gives the better explanation of how an ecosystem changes and why?” Thelma confidently stated “The second student’s model gives a better explanation, because it shows changes in time. The other model shows only a snapshot in time.” Louise dug even deeper, “Which model more clearly shows the relationships between the parts of the ecosystem and why?” Thelma replied “The first student’s model because it shows the relationships between parts of the ecosystem. The second student’s model shows changes in the ecosystem over time.”

Thelma asked Louise “What other models could be used to show some aspects of a forest ecosystem?” Louise simply said “A globe with different ecosystems labeled could be used to show how the forest ecosystem is related to other forest ecosystems in the world. Finally, Thelma asked “What technology could we use to help with our models?” “We could use a computer to research. We could also use binoculars to view objects from a distance.” Louise replied.

**DIRECTIONS** For each question, write your answer in the space provided

1. Why would scientists create models of atoms?

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2. Why would scientists make a three-dimensional model of a heart, as well as an illustration with labels?

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3. Mountains take a very long time to form. What is one reason to create a model of mountains forming?

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4. Which student's model gives the better explanation of how an ecosystem changes? Why?

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5. Which student's model more clearly shows the relationships between the parts of the ecosystem? Why?

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6. What other models could be used to show some aspects of a forest ecosystem?

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7. What technology could the students use to help with their models?

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8. Apply what you have learned from this scenario.

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## Lesson 7

### Elements and the Periodic Table

#### Focus on the NYS Learning Standards

- PS 3.3f** There are more than 100 elements. Elements combine in a multiple of ways to produce compounds that account for all living and nonliving substances. Few elements are found in their pure form.
- PS 3.3g** The periodic table is one useful model for classifying elements. The periodic table can be used to predict properties of elements (metals, nonmetals, noble gas).

#### Identify regions of the periodic table, including metals, nonmetals, and inert gases.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Jennifer and Carmen were getting ready for their chemistry final and were asking each other questions from their study guide to get prepared for the final. Jennifer began by asking Carmen to “List three properties you would expect the metal Zinc (Zn) to have.” Carmen replied “Shiny (lustrous), easy to shape (malleable), and highly conductive of both heat and electricity. Now it was Carmen’s turn, she asked Jennifer to “Locate Bromine (Br) on the periodic table. What two properties would you expect Bromine to have?” Jennifer replied “Brittle, and poor conductivity of heat and electricity.”

Jennifer shot back “Locate Titanium (Ti) on the periodic table. What type of element would you expect Titanium to be?” Carmen’s response was brief “Titanium is a metal.” She asked Jennifer to name three inert gasses. Jennifer answered “I will name more than that; Helium, Neon, Argon, Krypton, Xenon and Radon.” Not to be outdone, Carmen asked Jennifer to provide her with a list of ten elements and she classify each element as metal, nonmetal, or semimetal. She would also include whether each is also a transition metal or an inert gas.

Krypton (Kr)	Nonmetal; inert gas
Zirconium (Zr)	Metal; transition metal
Magnesium (Mg)	Metal
Chlorine (Cl)	Nonmetal
Arsenic (As)	Semimetal
Helium (He)	Nonmetal; inert gas
Oxygen (O)	Nonmetal
Copper (Cu)	Metal; transition metal
Silicon (Si)	Semimetal
Aluminum (Al)	Metal

Carmen then made a table for Jennifer that was only partially completed and asked her to use the information in the table to identify each unknown as a metal, nonmetal, or semimetal. The table looked like this:

<u>Sample</u>	<u>Reactivity</u>	<u>Conductivity of Electricity</u>	<u>Malleability</u>
Unknown 1	High	High	
Unknown 2	Low	Low	
Unknown 3	Medium	Medium	Can be shaped
Unknown 4	Medium	Low	

This was Jennifer's answer:

Unknown 1	Metal
Unknown 2	Nonmetal
Unknown 3	Semimetal
Unknown 4	Nonmetal

Carmen then asked Jennifer "Which column of the periodic table would you most expect Unknown 1 to be located in? Please explain your reasoning. Jennifer began with "Unknown 1 is a highly reactive metal. It is probably found in column 1 or 2 of the periodic table (Group 1 [1A] or group 2 [2A])."

Jennifer asked Carmen if she could "Fill in the rest of the table by predicting how easy is to shape each of the unknowns by hammering, bending, or applying pressure." For Unknown 1 she wrote easy to shape; for Unknown 2 she wrote hard or impossible to shape; and for Unknown 4 she put down hard to shape. Carmen then asked Jennifer "Which Unknown element would be most appropriate for filling the inside of a fluorescent lamp? Explain your answer. Jennifer responded "Unknown 2 is not a good conductor, so it is probably a nonmetal. It is not reactive, so it is probably an inert gas, and it could fill a lamp bulb.

Carmen had one last question for Jennifer, "You are told that one of the unknowns is in the same group as Barium (Ba) and shares many of the same properties. Which unknown is this most likely to be? And, of course, explain your reasoning." Jennifer deducted "Barium is a metal, so the correct unknown should have high conductivity and be easy to shape like most metals. Unknown 1 has those characteristics, so it could be in Barium's group."

**DIRECTIONS** For each question, write your answer in the space provided

1. List three properties you would expect the metal zinc (Zn) to have.

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2. Locate bromine (Br) on the periodic table. What two properties would you expect bromine to have?

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3. Locate titanium (Ti) on the periodic table. What type of element would you expect titanium to be?

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4. Name three inert gases.

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5. Classify each of the following elements as metal, nonmetal, or semimetal. Include whether each is also a transition metal or an inert gas.

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Krypton (Kr)

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Zirconium (Zr)

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Magnesium (Mg)

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Chlorine (Cl)

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Arsenic (As)

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Helium (He)

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Oxygen (O)

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Copper (Cu)

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Silicon (Si)

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Aluminum (Al)

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6. Use the information in the table to identify each unknown as a metal, nonmetal, or semimetal.

<b>Sample</b>	<b>Reactivity</b>	<b>Conductivity of Electricity</b>	<b>Malleability</b>
Unknown 1	High	High	
Unknown 2	Low	Low	
Unknown 3	Medium	Medium	can be shaped
Unknown 4	Medium	Low	

Unknown 1

Unknown 2

Unknown 3

Unknown 4

7. Which column of the periodic table would you most expect Unknown 1 to be located in? Explain your reasoning.

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8. Fill in the rest of the table by predicting how easy it is to shape each of the unknowns by hammering, bending, or applying pressure.

9. Which unknown element would be most appropriate for filling the inside of a fluorescent lamp? Explain your reasoning.

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**10.** You are told that one of the unknowns is in the same group as Barium (Ba) and shares many of the same properties. Which unknown is this most likely to be? Explain your reasoning.

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**11.** Apply what you have learned from this scenario.

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## Lesson 8

### Atoms and Molecules

#### Focus on the NYS Learning Standards

- PS 3.3a** All matter is made up of atoms. Atoms are far too small to see with a light microscope.
- PS 3.3b** Atoms and molecules are perpetually in motion. The greater the temperature, the greater the motion.
- PS 3.3c** Atoms may join together in well-defined molecules or may be arranged in regular geometric patterns.
- PS 3.3d** Interactions among atoms and/or molecules result in chemical reactions.

#### Explain how atoms interact with other atoms and with molecules in chemical reactions.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Jasmine and Symphony were friends since pre-school. They are sick of the stereotypes that they hear about cheerleaders and are determined to ace the chemistry final to change peoples' minds. They got together to quiz each other on possible test questions. Jasmine began by asking Symphony to "Compare the charge, location, and size of protons and electrons." Symphony replied "Protons are positively charged, and electrons are negatively charged. Protons are in the nucleus, and electrons surround the nucleus of an atom. Electrons are much smaller than protons."

Symphony said "Now my turn, describe how compounds form, Jasmine." She responded "Compounds form when two or more atoms come together and form a bond by sharing electrons." Jasmine came back with this question "How does the temperature of matter relate to the movement of the matter's molecules and atoms?" Symphony answered "A higher temperature will cause more movement." Symphony then drew a diagram with four balls in the nucleus with a letter N for neutron on them bunched together with three balls with a plus sign on them. Around the nucleus were two rings, one closer than the other. The ring closer to the nucleus had two balls on it with a minus sign on them. There was only one ball on the outer ring and it too had a minus sign on it. The balls in the nucleus with a plus sign on them represent protons and the ones on the rings with minus signs represent electrons.

Symphony then asked Jasmine "How could this diagram be improved to reflect what scientists now know about the shape of the paths of moving electrons?" Jasmine replied "Rather than showing the electron path as circles around the nucleus, it would be better to show the paths as three-dimensional clouds." Symphony drew a line to all of the balls clustered in the middle and labeled it A. She

then drew a line to one of the balls with a plus sign on it and labeled it B. Pointing to the ball with minus sign on it was the letter C. She then asked Jasmine to “Name the structures indicated by A, B and C in the diagram.” Jasmine answered “Label A indicates the nucleus of the atom, including both protons and neutrons. Label B indicates a positively charged proton in the nucleus. Label C indicates a negatively charged electron in the space around the nucleus.

Jasmine said “I have a question for you Symphony; what is the overall charge of the atom in the diagram? And would the atom be considered an ion?” Symphony responded “The overall charge is neutral, zero, or no charge. The atom would not be considered an ion, since it has no charge. The atom has the same number of protons as electrons.” “One last question,” Symphony continued, “your friends want to see an atom, so they place a piece of paper under a light microscope. They complain that they do not see anything that looks like an atom. What do your friends not realize?” Jasmine smartly said “My friends don’t realize that atoms are very small. They are too small to see with a light microscope.”

**DIRECTIONS** For each question, write your answer in the space provided

1. Compare the charge, location, and size of protons and electrons.

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2. Describe how compounds form.

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3. How does the temperature of matter relate to the movement of the matter’s molecules and atoms?

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4. How could Symphony’s diagram be improved to reflect what scientists now know about the shape of the paths of moving electrons?

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5. Name the structures indicated by A, B, and C in the diagram.

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6. What is the overall charge of the atom in the diagram? Would the atom be considered an ion?

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7. Your friends want to see an atom, so they place a piece of paper under a light microscope. They complain that they do not see anything that looks like an atom. What do your friends not realize?

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8. Apply what you have learned from this scenario.

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## Lesson 9

### Identifying Substances by Their Properties

#### Focus on the NYS Learning Standards

**PS 3.1a** Substances have characteristic properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points.

**PS 3.1g** Characteristic properties can be used to identify different materials, and separate a mixture of substances into its components. For example, iron can be removed from a mixture by means of a magnet. An insoluble substance can be separated from a soluble substance by such processes as filtration, setting, and evaporation.

#### Identify and separate substances according to properties such as hardness, conductivity, density, buoyancy, and solubility.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Watson and Sherlock liked solving mysteries. Sherlock would often quiz Watson and Watson would often defer to Sherlock when he baffled. Sherlock asked Watson “Before you can determine the density of a substance, what two measurements do you need to know?” Watson replied, “You need to know the mass and volume of the substance.” “Now Watson, said Sherlock, “explain how the densities of two liquids can be used to determine which liquid will float and which will sink.” Watson responded “Compare the two densities. The liquid with the lower density will float on top of the liquid with the higher density.”

Watson asked Sherlock “What makes diamond a good substance for blades that cut very hard materials?” Sherlock replied, “Diamonds have a very high value of hardness and will not break against another hard surface.” Sherlock stated “The element iron has a hardness of around 4.0. Which element from the table below can scratch iron?”

<b>Element</b>	<b>Hardness</b>	<b>Density</b>
Boron	9.3	2.3
Gallium	1.5	5.9
Selenium	2.0	4.8

Watson answered, “Boron can scratch iron, because it has a higher hardness.” “Alright Watson, you are given 1 mL of each substance above. Which sample has the highest mass?” Watson responded, “The sample of Gallium has the highest mass, because it is the densest.”

“Tell me this Watson, a sample of each of the above elements is submerged in a liquid with a density of about 3.0 g/mL. Which sample(s) will float and which will sink?” He replied, “Boron will float because it is less dense than the liquid, while selenium and gallium will sink since they are denser than the liquid.” “What if I provide you with a sample and tell you it is one of the three elements in the table. You measure the mass to be 360 g and the volume to be 75 mL. Which element, Watson, is the sample?” Watson took a few minutes, and then said, “The element is selenium. Density equals mass over volume.  $360 \text{ g} \div 75 \text{ mL} = 4.8 \text{ g/mL}$ , which is the density of selenium.”

**DIRECTIONS** For each question, write your answer in the space provided

1. Before you can determine the density of a substance, what two measurements do you need to know?

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2. Explain how the densities of two liquids can be used to determine which liquid will float and which will sink.

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3. What makes diamond a good substance for blades that cut very hard materials?

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4. The element iron has a hardness of around 4.0. Which element in the previous table can scratch iron?

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5. You are given 1 mL of each substance in the table. Which sample has the highest mass?

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6. A sample of each of the elements in the table is submerged in a liquid with a density of about 3.0 g/mL. Which sample(s) will float and which will sink?

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7. Your teacher provides you with a sample and tells you it is one of the three elements in the table. You measure the mass to be 360 g and the volume to be 75 mL. Which element is the sample?

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8. Apply what you have learned from this scenario.

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## Lesson 10

### Kinetic Theory and Phases of Matter

#### Focus on the NYS Learning Standards

- PS 3.1c** The motion of particles helps to explain the phases (states) of matter as well as changes from one phase to another. The phase in which matter exists depends on the attractive forces among its particles.
- PS 4.2c** During a phase change, heat energy is absorbed or released. Energy is absorbed when a solid changes to a liquid and when a liquid changes to a solid.

**The kinetic theory of matter helps explain the relationship between the phase a material is in and the way its particles are moving.**

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Chip and Dale are twins, though they both enjoy swimming in the summer, they also enjoy skating in the winter. They were studying for a physical science test and noticed that much of the material affected their everyday life. Chip began by asking “What are the properties of a gas?” Dale replied, “Its particles move freely.” Then added, “Gas has no definite shape or volume.” Dale then asked Chip “What occurs at the freezing point of a substance?” Chip responded “The substance changes from the liquid state to the solid state.”

“Ok Dale, tell me what does the kinetic theory of matter explain?” Dale answered “The relationship between the movement of atoms and molecules in various states of matter.” “Chip, the temperature at which a substance melts and freezes is the same. What determines which state will form?” “Well Dale, whether the substance is gaining or losing energy.” “Dale, explain the relationships between ice, liquid water, water vapor, molecular motion, and heat.” “Well Chip, ice has atoms that are closely locked in position and can only vibrate. As heat is added, the molecular motion increases. At the melting point, the molecules move faster so they can move past each other to change into the liquid state. As more heat is added, the molecules can move freely past each other to become water vapor.”

<b>Kind of Matter</b>	<b>Boiling/Condensation Points (C)</b>	<b>Melting/Freezing Points (C)</b>
Helium	-269	-272
Hydrogen	-252	-259
Oxygen	-184	-219
Water	100	0
Mercury	357	-39
Lead	1,740	328
Aluminum	2,467	658

Chip made a chart like the one above with melting / freezing points and boiling / condensation points of certain elements. Then he asked Dale "What happens at 650 C to aluminum if you add energy to it?" Dale said "That's simple, it melts." Then Chip asked Dale to "Compare the freezing point and the melting point of lead." Dale answered "The freezing point is the point at which lead turns from liquid to solid. The melting point is the point at which solid lead turns to liquid. The temperature for both points is the same. Whether heat is added or removed determines the result."

"Dale, using the kinetic theory of matter, explain how molecules of water at 125 C behave differently than molecules of water at 85 C." Dale responded by saying "Water at 125 C is a gas, which means that molecules are moving freely. Water at 85 C is a liquid. The molecules are moving more slowly than the gas molecules. The liquid molecules can slide past one another, but they cannot move about freely."

Chip had one final question for Dale; he started by saying "People use copper for many different purposes, including making copper wire, tubes, and pipes. Copper pipes can transport liquid water that is extremely hot. Why is it that the copper pipes remain solid while the hot liquid flows through them?" Dale responded, "Even the hottest liquid water is probably not hotter than 100 C, or else it would change from a liquid to a gas. Copper has a melting point of 1,080 C. The hot water in the copper pipes is still not nearly hot enough to melt the pipes."

**DIRECTIONS** For each question, write your answer in the space provided

1. What are the properties of a gas?

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2. What occurs at the freezing point of a substance?

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3. What does the kinetic theory of matter explain?

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4. The temperature at which a substance melts and freezes is the same. What determines which state will form?

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5. Explain the relationships between ice, liquid water, water vapor, molecular motion, and heat.

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6. What happens to aluminum at 658 C if you add energy to it?

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7. Compare the freezing point and the melting point of lead.

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8. Using the kinetic theory of matter, explain how molecules of water at 125 C behave differently than molecules of water at 85 C.

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9. People use copper for many different purposes, including making copper wire, tubes, and pipes. Copper pipes can transport liquid water that is extremely hot. Why is it that the copper pipes remain solid while hot liquid water flows through them?

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10. Apply what you have learned from this scenario.

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## Lesson 11

### Physical and Chemical Changes

#### Focus on the NYS Learning Standards

**PS 3.2a** During a physical change, a substance keeps its chemical composition and properties. Examples of physical changes include freezing, melting, condensation, boiling, evaporation, tearing, and crushing.

**PS 3.2c** During a chemical change, substances react in characteristic ways to form new substances with different physical and chemical properties. Examples of chemical changes include burning of wood, cooking of an egg, rusting of iron, and souring of milk.

#### Identify changes as chemical or physical, determine the direction of a reaction and its products, and learn how to balance a chemical equation.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Barbie and Ken were an item for quite a while. People said that together they were as cute as a pair of dolls. Recently they both noticed their relationship going through some changes which coincided with the subject matter that they were studying together. Barbie began by asking Ken “What type of change is tearing a piece of paper into small pieces?” To which Ken replied “A physical change”

Ken asked Barbie “What happens in a chemical reaction?” She responded “The atoms in the reactants rearrange to form new compounds with different properties.” Barbie then asked Ken “If you put an egg into a pot of boiling water, the egg will turn from a liquid to a solid. It will also change color – the clear liquid turns white. The change is not reversible. Based on this information, which type of change does an egg go through as it cooks?” Ken answered “A chemical change.”

Barbie then asked Ken “What is the law of conservation of mass?” Ken replied “Matter can neither be created nor destroyed in ordinary chemical reactions.” Then she asked “If all the reactants in a reaction together have a mass of 58.2 g what would be the mass of the products after the reaction?” Ken simply answered “58.2 g.” Ken then asked Barbie “What does it mean when a chemical equation is balanced?” Barbie replied “The equation shows that the mass of the products is equal to the mass of the reactants.”

Barbie then produced a table that grouped elements by their reaction:

<u>Metals</u>	<u>Nonmetals</u>	<u>Noble Gasses</u>
Occur naturally as solids and liquids on Earth. Generally shiny and metallic	Occur naturally as solids, liquids, and gases on Earth. Solid nonmetals are	All are gases. nonreactive.

in appearance. Conduct electricity well. Some have magnetic properties.  
Iron, Copper, Mercury

generally not shiny and can be brittle. Generally poor conductors of electricity.  
Oxygen, Carbon, Nitrogen

Helium,  
Argon, Xenon

Barbie then asked Ken “If you had a sample of an unknown substance that was shiny, flexible, and conducted electricity, which group would you be most likely to place it in, and explain why.” Ken responded “I would place it in the metals group because the substance has the most in common with those elements.”

“Ok Ken, say you and a classmate decide to see what kind of reaction happens when you mix iron filings and grains of sand. After the materials are mixed, you observe the mixture. You do not see a color change. You do not feel any temperature change in the jar. What can you determine from the experiment?” Ken answered, “The substances did not react chemically when mixed together. Even though they are mixed, the iron filings are still chemically separate from the grains of sand.”

Barbie then asked Ken if he could easily separate the mixture of iron filings and sand. If so, “Describe how you would do it. Use the table I created to figure out a solution.” Ken said, “Yes, I could separate the mixture. The table says that iron is magnetic. I could use a magnet to pull all the iron out of the mixture.” Barbie had one last question for Ken “You have a substance that is nonreactive and is liquid at room temperature. Based on this information, can you determine whether it is a metal, nonmetal, or noble gas? And please explain.” Ken replied “No, I cannot tell. I know it is not a noble gas, because it is a liquid. But I cannot know from the information given if it is a metal or a nonmetal.”

**DIRECTIONS** For each question, write your answer in the space provided

1. Tearing a piece of paper into small pieces is what type of change?

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2. What happens in a chemical reaction?

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3. If you put an egg into a pot of boiling water, the egg will turn from a liquid to a solid. It will also change color – the clear liquid turns white. The change is not reversible. Based on this information, which type of change does an egg go through as it cooks?

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4. What is the law of conservation of mass?

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5. If all the reactants in a reaction together have a mass of 58.2 g, what would be the mass of the products after the reaction?

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6. What does it mean when a chemical equation is balanced?

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7. According to the table, if you had a sample of an unknown substance that was shiny, flexible, and conducted electricity, which group would you be most likely to place it in? Explain your reasoning.

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8. You and a classmate decide to see what kind of reaction happens when you mix iron filings and grains of sand. After the materials are mixed, you observe the mixture. You do not see a color change. You do not feel any temperature change in the jar. What can you determine from the experiment?

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9. Could you easily separate the mixture described in question 2? If so, describe how you would do it. Use the table above to help you figure out a solution.

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10. You have a substance that is nonreactive and is liquid at room temperature. Based on this information, can you determine whether it is a metal, nonmetal, or noble gas? Explain your answer.

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11. Apply what you have learned from this scenario.

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## Lesson 12

### Forms of Energy

#### Focus on the NYS Learning Standards

**PS 4.1a** The Sun is a major source of energy for Earth. Other sources of energy include nuclear and geothermal energy.

**PS 4.1d** Different forms of energy include heat, light, electrical, mechanical, sound, nuclear, and chemical. Energy is transformed in many ways.

#### Demonstrate an understanding of the forms of energy and of energy transformations.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Noah and his dad were watching Noah's little brother Billy's football practice. Noah noticed how much energy his little brother was using up during his football practice. It was an appropriate concern since their dad promised to help him with his upcoming science test on energy. His dad started out by asking Noah to "Name at least five different forms of energy. Noah gave more than five examples; "Chemical energy, solar energy, light energy, mechanical energy, nuclear energy, sound energy, electrical energy, and thermal energy."

He then asked Noah "What does a hamburger have in common with gasoline?" Noah replied "Both contain chemical energy." "Noah, tell me, what is light, and how do we see it?" Noah answered "Light is electromagnetic waves within a certain range of frequencies, which we see when they enter our eyes." Noah's dad then told him that "The eye has two different receptors; rods and cones. Rods react to low or dark light and cones react to bright light. He constructed a table with the different types of cones, wavelengths, and colors.

<b>Kind of Cone</b>	<b>Wavelength in Nanometers (Nm)</b>	<b>Colors the Cones Respond to</b>
L (long) cone	564	Green, red, yellow, orange
M (medium) cone	534	Green, blue
S (short) cone	420	Violet

He then asked Noah to "Explain why visible light can have different colors." Noah responded "Visible light is split into a range of wavelengths. Each wavelength has its own color." "And why does the human eye see colors?" Noah replied, "The human eye sees colors because there are cells called cones on the retina that are

sensitive to the wavelengths of color.” “One last question Noah, using the information in the table I created, infer to which color is the most sensitive to the eye, and explain why.” Noah answered, “The human eye is most sensitive to green light, because the light of that wavelength stimulates two of the three kinds of cones.”

**DIRECTIONS** For each question, write your answer in the space provided

1. Name at least five different forms of energy.

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2. What does a hamburger have in common with gasoline?

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3. What is light, and how do we see it?

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4. Explain why visible light can have different colors.

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5. How does the human eye see colors?

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6. Using the information in the table, infer to which color the eye is most sensitive.  
Explain your answer.

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7. Apply what you have learned from this scenario.

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## Lesson 13

### Energy Changes

#### Focus on the NYS Learning Standards

- PS 4.1c** Most activities in everyday life involve one form of energy being transformed into another. For example, the chemical energy in gasoline is transformed into mechanical energy in an automobile engine. Energy, in the form of heat, is almost always one of the products of energy transformations.
- PS 4.1e** Energy can be considered to be either kinetic energy, which is the energy of motion, or potential energy, which depends on relative position.
- PS 4.2a** Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.

#### Energy can be transferred from place to place in many ways.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Mork and Mindy are an interesting couple. When you hear the expression ‘opposites attract’, they’re talking about Mork and Mindy. Mork is like a character from outer space, very weird. Mindy, on the other hand, is very stable and down to earth. They share a Physics class and were boning up for an upcoming quiz on energy. Mork began by asking “What kind of energy does a book have when it is sitting high on a bookshelf?” Mindy replied “Potential energy.”

Mork then asked “What form of energy comes from inefficiency in energy transfers?” Mindy simply answered “Heat.” He then asked Mindy “What are the three ways in which heat is transferred?” Mindy replied “Conduction, convection, and radiation.” Mork then drew a picture of a boy sitting on a log in front of a campfire holding a wooden stick with a hot dog on the other end over the fire. He then asked Mindy to “Describe how convection currents above the bonfire would be moving.” Mindy responded “The air heated by the fire rises, replacing cooler air. As it cools, it moves down again. When it is heated, it rises up again.”



Mork then asked Mindy “Besides convection, name and describe two other ways in which energy is being transferred in the scene shown in the picture.” And he gave Mindy a hint: “They will both be experienced by the student who is sitting in front of the fire.” Mindy responded “The heat from the fire is transferred as radiation, which the student feels. Heat can also be transferred by conduction through the stick the student is holding, which is heated up by the fire.”

“One last question Mindy, how might the camper experience the heat from the fire differently if the camper were to cook the hot dog on a metal wire instead of a stick?” Mindy answered “The camper would feel the heat through a metal wire much more than through a stick, because heat moves through metal better than through wood.

**DIRECTIONS** For each question, write your answer in the space provided

1. What kind of energy does a book have when it is sitting high on a bookshelf?

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2. What form of energy comes from inefficiency in energy transfers?

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3. What are the three ways in which heat is transferred?

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4. Describe how convection currents above the bonfire would be moving.

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5. Besides convection, name and describe two other ways in which energy is being transferred at the bonfire. (Hint: They will both be experienced by the student who is sitting in front of the fire).

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6. How might the student experience the heat from the fire differently if the student were to cook the hot dog on a metal wire instead of a stick?

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7. Apply what you have learned from this scenario.

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## Lesson 14

### Energy Resources

#### Focus on the NYS Learning Standards

- PS 4.1b** Fossil fuels contain stored solar energy and are considered nonrenewable resources. They are a major source of energy in the United States. Solar energy, wind, moving water, and biomass are examples of renewable energy resources.
- PS 4.1d** Electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy.

#### Explain renewable and nonrenewable resources and the effects of human activity on Earth's resources.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Tim and Tom were twins. They did everything together. When I say everything, I mean everything, like playing sports, wearing clothes and even finishing each other's sentences. On this evening, they were comparing science notes and noticing how much of science is intertwined, such as biology, chemistry, environmental science, and physics. Tim started out by asking Tom a biology related question, "Why it is true to say that petroleum is stored energy from the sun?" Tom replied, "Ancient plants used solar energy to make glucose, which is stored energy. Then over millions of years the decayed plants turned into petroleum, so petroleum is stored solar energy."

Tom asked Tim "What are examples of nonrenewable energy sources and renewable or inexhaustible energy resources?" Tim responded, "Nonrenewable are coal, natural gas, and petroleum. Renewable or inexhaustible are solar, wind, moving water, and biomass." Tom then asked Tim "How does preventing pollution help make resources last longer?" Tim answered "Some resources can become unusable if they are polluted. By preventing pollution, we make sure resources are not wasted by becoming unusable."

Tim then asked Tom "What are some advantages of using inexhaustible energy resources such as the wind?" Tom answered, "Inexhaustible energy resources do not pollute the environment and are in endless supply." Tim then drew a graph with three possible depletion times for a nonrenewable resource. Condition A was the highest in production but shortest in depletion time, it was mined, used and then thrown away. Condition B was the second highest in production and longer in depletion time. Recycling and increasing reserves by

improved mining technology was used here. Condition C was lowest in production but longest in depletion time. Recycle, reuse and reduce consumption by improving mining technology was implemented here.

Tim then asked Tom, "Under which condition does the resource last the shortest time?" Tom replied, "When people use the resource and throw it away with no recycling or conservation as in condition A." Tim then asked Tom, "What does recycling a resource do to the amount of time the resource is available?" Tom responded, "Recycling Increases the amount of time the resource is available."

Tim inquired of Tom "What, in addition to recycling, can help a resource last the longest?" Tom answered, "Reusing a resource, reducing the use of the resource through conservation, and discovering more of the resource." Tim then asked, "How does the depletion time of Condition A compare to that of Condition C?" Tom replied "The depletion time of Condition A is much faster than that of Condition C." "One last question Tom, infer why fossil fuels are the main source of energy for the United States." Tom answered, "Burning a small amount of fossil fuels produces a great amount of energy."

**DIRECTIONS** For each question, write your answer in the space provided

1. Why is it true to say that petroleum is stored energy from the Sun?

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2. What are examples of nonrenewable energy sources and renewable or inexhaustible energy resources?

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3. How does preventing pollution help make resources last longer?

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4. What are some advantages of using inexhaustible energy resources such as the wind?

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5. Under which condition mentioned previously does the resource last the shortest time?

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6. What does recycling a resource do to the amount of time the resource is available?

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7. What, in addition to recycling, can help a resource last the longest?

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8. How does the depletion time of Condition A compare to that of Condition C?

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9. Infer why fossil fuels are the main source of energy for the United States.

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**10.** Apply what you have learned from this scenario.

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## Lesson 15

### Speed, Velocity, and Acceleration

#### Focus on the NYS Learning Standards

**PS 5.1a** The motion of an object is always judged with respect to some other object or point. The idea of absolute motion or rest is misleading.

**PS 5.1b** The motion of an object can be described by its position, direction of motion, and speed.

#### Demonstrate an understanding of motion.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Flojo and Lolo were both track stars. It was appropriate that the unit of study in science class was motion, speed and such. Flojo began by asking Lolo “What are three things that describe motion?” Lolo replied “Position with respect to background, speed, and direction.” Flojo then asked, “What does it mean when the line on a graph of distance vs. time changes direction?” Lolo answered, “The speed is changing.”

Flojo then inquired, “How is average speed calculated?” Lolo responded, “The total distance is divided by the total time.” She then asked “If the object changing speed on a graph was slowing down rather than speeding up, how would the line look?” Lolo replied, “The line would continue going up but would be less steep.” Flojo then asked, “Why don’t all falling objects have an acceleration of 9.8 m/s squared?” Lolo answered, “Objects that fall through the air experience air resistance. Air resistance on a falling object is an upward force that opposes the downward force of gravity.”

Flojo then drew a graph of distance vs. time. Then she asked Lolo, “What is the object doing between points A and B?” On the Y axis the graph was labeled Distance (m) and on the X axis it was labeled Time (s). Point A was at 0,0 and point B was at 2,3 so Lolo responded, “It is moving forward a distance of 3 meters at a constant speed.” Flojo then asked “What is object doing between points B and C?” Since the coordinates of points B and C were 2,3 and 5,3 respectively Lolo simply replied, “It is stopped.” Flojo inquired, “What is the average speed from point A to point C?” Lolo answered, “It traveled 3 meters in 5 seconds, so its average speed is 0.6 m/s.”


Plot points A, B & C and connect them with lines.

Flojo then asked Lolo, "What is the object doing between points C and D?" The coordinates for points C and D are 5,3 and 8,0 respectively so Lolo responded, "It is moving 3 meters backward." Flojo then asked Lolo one last question, "How can you tell whether the object's speed is constant between points A and B and between points C and D?" Lolo replied, "Between points A and B, the object travels 1.5 meters in 1 second and 3 meters in 2 seconds. Between points C and D, it travels 1 meter in 1 second, 2 meters in 2 seconds, and 3 meters in 3 seconds. Both lines between points A and B and points C and D have a constant slope."

**DIRECTIONS** For each question, write your answer in the space provided

- 1. What are three things that describe motion?

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- 2. What does it mean when the line on a graph of distance vs. time changes direction?

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- 3. How is average speed calculated?

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4. If the object changing speed in the graph on the previous page was slowing down rather than speeding up, how would the line look?

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5. Why don't all falling objects have an acceleration of  $9.8 \text{ m/s}^2$ ?

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6. On the graph Flojo drew, what is the object doing between points A and B?

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7. On Flojo's graph, what is the object doing between points B and C?

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8. What is the average speed from point A to point C?

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**9.** What is the object doing between points C and D?

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**10.** How can you tell whether the object's speed is constant between points A and B and between points C and D?

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**11.** Apply what you have learned from this scenario.

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## Lesson 16

### Force and Motion

#### Focus on the NYS Learning Standards

**PS 5.1c** An object's motion is the result of the combined effect of all forces acting on the object. A moving object that is not subjected to a force will continue to move at a constant speed in a straight line. An object at rest will remain at rest.

**PS 5.1e** For every action there is an equal and opposite reaction.

#### Demonstrate an understanding of the way that forces affect motion.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Laverne and Shirley were studying the Renaissance in social studies class and were surprised that in science class one of the heroes name was mentioned. It was Sir Isaac Newton and his laws of physics. Laverne asked Shirley to describe Newton's first law of motion in her own words. Shirley replied, "Objects at rest stay at rest and objects in motion stay in motion with the same velocity unless acted upon by an unbalanced force."

Then Laverne asked Shirley to "Give an example of Newton's Third Law of Motion." Shirley answered, "When a canoe paddle exerts a force on the water, the water exerts an equal and opposite force on the paddle, which pushes the canoe forward." Shirley said that first social studies and science were connected by Newton, now science and math were connected as she asked Laverne "What force is necessary to accelerate a 1,200 kg car at a rate of 35 m/s squared?" Laverne wrote down he answer;  $F = ma$ ;  $F = 1,200 \text{ kg} \times 35 \text{ m/s squared} = 42,000 \text{ N}$ . Shirley then asked "How much acceleration would the car have if a 30,600 N force was applied to the car?" Laverne wrote down the following answer:

$$a = \frac{30,600 \text{ N}}{1,200} = 25.5 \text{ m/s squared}$$

Laverne then asked Shirley "How does a seatbelt help you when the car you are riding in stops suddenly? To which law of motion does this apply?" Shirley answered, "The seatbelt keeps me in my seat. Without the force of the seatbelt pushing me backward, I would fall forward when the stops suddenly. This applies to the first law of motion." Laverne asked Shirley to explain "Why Newton's First Law of Motion can be difficult to observe in moving objects." She answered, "Newton's First Law describes the motion of objects that have no unbalanced forces

acting on them. The law can be difficult to observe because an unbalanced force of friction usually acts on the moving object.”

Laverne said “The force of friction between a ball and a wooden floor is less than the force of friction between the same ball and a carpeted floor. Suppose that you push the ball with the same force on both the wooden floor and the carpeted floor. Apply Newton’s Second Law of Motion to explain why the ball does not roll as far on the carpeted floor.” Shirley responded, “According to Newton’s Second Law, the acceleration of an object is equal to the force applied divided by the mass of the object. The force of friction is greater on the carpet, so the acceleration in the backward direction is greater. Therefore, the ball will slow down more quickly and stop sooner on the carpeted floor.”

Laverne then told Shirley to “Apply Newton’s Third Law of Motion to explain why a ball that is rolled into a wall bounces back after hitting the wall.” Shirley replied, “When the ball hits the wall, it exerts a force on the wall. According to Newton’s Third Law, the wall exerts an equal and opposite force on the ball. That opposite force pushes the ball backward.”

**DIRECTIONS** For each question, write your answer in the space provided

1. Describe Newton’s first law of motion in your own words?

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2. Give an example of Newton’s third law of motion?

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3. What force is necessary to accelerate a 1,200 kg car at a rate of 35 m/s squared? How much acceleration would the car have if a 30,600-N force was applied to the car?

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4. How does a seatbelt help you when the car you are riding in stops suddenly? To which law of motion does this apply?

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5. Explain why Newton's first law of motion can be difficult to observe in moving objects.

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6. The force of friction between a ball and a wooden floor is less than the force of friction between the same ball and a carpeted floor. Suppose that you push the ball with the same force on both the wooden floor and the carpeted floor. Apply Newton's second law of motion to explain why the ball does not roll as far on the carpeted floor.

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7. Apply Newton's third law of motion to explain why a ball that is rolled into a wall bounces back after hitting the wall.

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8. Apply what you have learned from this scenario.

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## Lesson 17

### Work and Machines

#### Focus on the NYS Learning Standards

**PS 5.2c** Machines transfer mechanical energy from one object to another.

**PS 5.2f** Machines can change the direction or amount of force, or the distance or speed of force required to do work

**PS 5.2g** Simple machines include a lever, a pulley, a wheel and axle, and an inclined plane. A complex machine uses a combination of interacting simple machines, e.g., a bicycle.

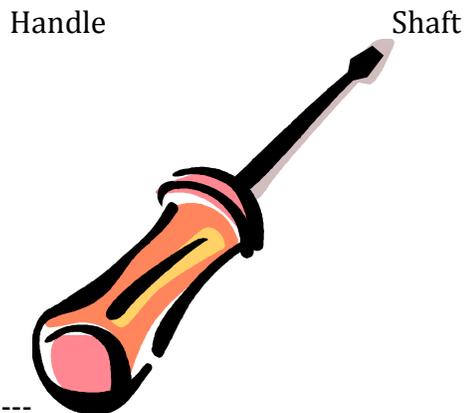
#### Demonstrate an understanding of the function of machines.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Arnold and Lou lifted weights together. They were amazed at how much easier their workouts were when they used the machines. It was appropriate because in science class they were also learning about machines. Arnold began their study session by asking Lou to “Describe what machines do.” Lou replied, “They make a task easier by changing the amount or direction of a force, or the distance or speed of force needed to perform a task.”

Arnold then asked Lou to “List three everyday objects that are simple machines.” Lou responded, “Lever – bottle opener, crowbar, shovel, seesaw; inclined plane – stairs, ramp, hill; pulley – clothesline pulley, rigging on a sailboat; wheel and axle – bicycle wheel, pizza cutter.” Arnold followed with the following, “What two measurements are needed to calculate the ideal mechanical advantage (IMA) of a lever?” Lou answered, “The lengths of the effort arm and the resistance arm.”

Arnold had a math problem for Lou, “What is the percent efficiency of a ramp if the work input is 4,800 J and the output is 3,200 J? Show your work. Round your answer to the nearest percent.” Lou simply wrote the following:  $(3,200 / 4,800) \times 100 = 67 \%$ . Lou then drew a picture of a screwdriver and labeled it:



He then asked Lou, “What is the force at the handle?” Lou replied, “The force at the handle is an effort force.” Arnold, happy with the answer, then inquired, “What is the force at the shaft?” Lou responded, “The force at the shaft is a resistance force.”

Arnold then asked Lou to “Compare the size of the effort force to the size of the resistance force.” Lou answered, “The effort force is less than the resistance force.” He then asked Lou to “Explain how a screwdriver can be used as a wheel and axle and how it can be used as a lever.” Lou replied, “The screwdriver acts as a wheel and axle when you use it to turn a screw. The screwdriver acts as a lever when you use it to pry open a can of paint.” “One last request,” Arnold said, “Recommend a change to the design of the screwdriver so that it will have a higher ideal mechanical efficiency.” Lou responded, “Make the handle have a larger radius.”

**DIRECTIONS** For each question, write your answer in the space provided

1. Describe what machines do.

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2. List three everyday objects that are simple machines.

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3. What two measurements are needed to calculate the IMA of a lever?

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4. What is the percent efficiency of a ramp if the work input is 4,800 J and the output is 3,200 J? Show your work. Round your answer to the nearest percent.

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5. A screwdriver is a tool that drives a screw when the handle is turned. What is the force at the handle?

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6. What is the force at the shaft?

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7. Compare the size of the effort force to the size of the resistance force.

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8. Explain how a screwdriver can be used as a wheel and axle and how it can be used as a lever.

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9. Recommend a change to the design of the screwdriver so that it will have a higher ideal mechanical efficiency.

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10. Apply what you have learned from this scenario.

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## Lesson 18

### Electrical Force

#### Focus on the NYS Learning Standards

**PS 4.4d** Electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy.

**PS 4.4e** Electrical circuits provide a means of transferring electrical energy.

#### Demonstrate an understanding of static electricity, current, and circuits.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Ben and George liked to invent things. They loved the current unit in science, no pun intended, because it concerned electricity, which played a major role in their inventions. Ben began their study session by asking George “What is static electricity?” George replied, “Static electricity is the buildup of electric charge in an object.” Ben then asked George to “Find the voltage of a circuit with a current of 5 A and a resistance of 3 ohms.” George used Ohm’s Law: Voltage = Current x Resistance ( $V = A \times \text{ohms}$ ), so, he wrote  $V = 5 A \times 3 \text{ ohms}$ , or  $V = 15$ .

Ben then asked “What properties does the resistance of an object depend on?” George responded, “Material, thickness, length, temperature, presence or lack of ions.” Ben then asked George, “How could you find out if a circuit is a series or parallel circuit?” George answered, “None of the loads in a series circuit will work if there is a break in the circuit, but other loads in a parallel circuit can continue to work even if one of the loops is broken.”

Ben said to George “Suppose you are doing an experiment with static electricity. You have a negatively charged balloon and a plastic comb. You do not know whether the comb is positively charged or negatively charged. What can you do to determine the charge on the comb?” George replied, “I would place the balloon on a desk where it can move freely and then hold the comb near the balloon. If the balloon moves toward the comb, the comb is positively charged. If the balloon moves away from the comb, the comb is negatively charged.”

Ben started the next question by stating that “The protons in an atom are in the nucleus. The electrons of the atom move around the nucleus. What keeps the electrons from moving away from the nucleus?” George responded, “Protons are positively charged and electrons are negatively charged. The electric force between

the electrons and the protons keep the electrons from moving away from the nucleus.

Ben told George “If you charge a balloon by rubbing it on your hair and then put the balloon against a wall, the balloon will stick to the wall. The charge on the balloon induces a positive charge on the wall and an electric force between the balloon and wall causes the balloon to stick. If you leave the balloon alone, it will eventually fall off the wall. Explain why.” George answered, “The static electricity built up on the balloon will discharge slowly over time. Once the balloon loses its charge, it will no longer be held to the wall by the electric force.” “One last question,” Ben said, “strings of many small lights are often connected in a series circuit. What is a possible drawback of this arrangement?” George replied, “A possible drawback of this arrangement is that if one of the light bulbs goes out, the entire string of lights will go out.”

**DIRECTIONS** For each question, write your answer in the space provided.

1. What is static electricity?

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2. Find the voltage of a circuit with a current of 5 A and a resistance of 3 ohms.

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3. What properties does the resistance of an object depend on?

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4. How could you find out if a circuit is a series or parallel circuit?

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5. Suppose you are doing an experiment with static electricity. You have a negatively charged balloon and a plastic comb. You do not know whether the comb is positively charged or negatively charged. What can you do to determine the charge on the comb?

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6. The protons in an atom are in the nucleus. The electrons of the atom move around the nucleus. What keeps the electrons from moving away from the nucleus?

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7. If you charge a balloon by rubbing it on your hair and then put the balloon against a wall, the balloon will stick to the wall. The charge on the balloon induces a positive charge on the wall and an electric force between the balloon and wall causes the balloon to stick. If you leave the balloon alone, it will eventually fall off the wall. Explain why.

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8. Strings of many small lights are often connected in a series circuit. What is a possible drawback of this arrangement?

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9. Apply what you have learned from this scenario.

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## Lesson 19

### Magnetic Force

#### Focus on the NYS Learning Standards

- PS 4.4f** Without touching them, material that has been electrically charged attracts uncharged material, and may either attract or repel other charged material.
- PS 4.4g** Without direct contact, a magnet attracts certain materials and either attracts or repels other magnets. The attractive force of a magnet is greatest at its poles
- PS 5.2b** Electric currents and magnets can exert a force on each other.

#### **Demonstrate an understanding of magnetism, electromagnets, and electromagnetic induction.**

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Magneto and Titanium man were the names of the super heroes that Paul and John most like to read about when they read their comic books. They would wait all week until Saturday afternoon so that they could go to the neighborhood deli and buy Blue Boy orange soda, and barbeque potato chips. And then each would have their own bag of chips and can of soda, and some brand new comic books. Then they would go home and read, laying on the couch or bed, while snacking and drinking and reading. So it was fitting that this week's science study session was about magnetic force.

Paul began by asking John to "Name and describe two kinds of magnets." John replied, "Ferromagnets are magnets that contain iron, nickel, or cobalt. Electromagnets are magnets that are made by an electric current." Paul said, "A wire has been wrapped around a magnet. Explain why no current is induced in the wire and explain what must be done to induce a current." John responded, "A current will be induced only when the magnetic field around the wire changes. Either the magnet must be moved or the wire must be moved to induce a current."

Paul next asked John to "Describe how you would build an electromagnet." John answered, "To make an electromagnet, wrap a current-carrying wire around an iron core." Paul began his next question by stating, "The north pole of a bar magnet will point in a northern direction if allowed to rotate. Apply your knowledge of magnets to determine whether the magnetic pole near Earth's geographic North

Pole is a magnetic north pole or a magnetic south pole. Explain your answer.” John replied, “The magnetic pole near Earth’s geographic North Pole is a magnetic south pole. Opposite poles of a magnet attract each other, so the north pole of a bar magnet will be attracted to the south pole of another magnet, such as the magnetic south pole of Earth.”

Paul stated, “A compass is a device that contains a needle that points to the north. Explain how a compass works.” John responded, “The needle in a compass is a small magnet that is free to rotate. The magnet points to Earth’s magnetic pole.” Paul then asked John to “Describe how the balance of magnets would change if Earth’s magnetic poles flipped.” John answered, “If Earth’s magnetic poles flipped, the north poles of magnets would point to the south instead of the north.” “One final question John,” Paul continued, “compass needles do not point to Earth’s geographic North Pole. Could this fact be a problem for people who use compasses to navigate?” John replied, “The fact that ompass needles do not point to Earth’s geographic North Pole is not a problem for most people because the geographic and magnetic poles are close together. However, that fact could be a problem for people located near the poles.”

**DIRECTIONS** For each question, write your answer in the space provided.

1. Name and describe two kinds of magnets.

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2. A wire has been wrapped around a magnet. Explain why no current is induced in the wire and explain what must be done to induce a current.

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3. Describe how you would build an electromagnet.

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4. The north pole of a bar magnet will point in a northern direction if allowed to rotate. Apply your knowledge of magnets to determine whether the magnetic pole near Earth's geographic North Pole is a magnetic north pole or a magnetic south pole. Explain your answer.

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5. A compass is a device that contains a needle that points to the north. Explain how a compass works.

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6. Describe how the behavior of magnets would change if Earth's magnetic poles flipped.

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7. Compass needles do not point to Earth's geographic North Pole. Could this fact be a problem for people who use compasses to navigate?

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8. Apply what you have learned from this scenario.

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## Lesson 20

### The Sun and the Solar System

#### Focus on the NYS Learning Standards

**PS 1.1a** Earth's Sun is an average-sized star. The Sun is more than a million times greater in volume than Earth.

**PS 1.1c** The Sun and the planets that revolve around it are the major bodies in the solar system. Other members include comets, moons, and asteroids. Earth's orbit is nearly circular.

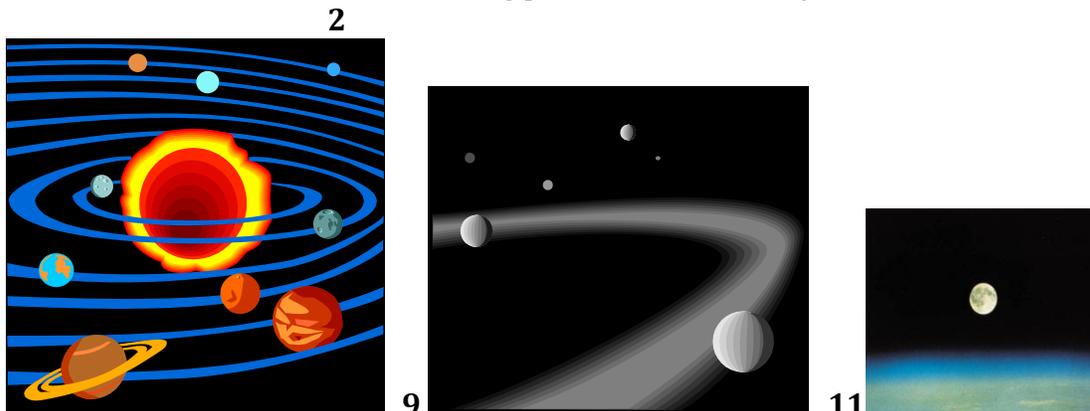
#### Understand the features of the objects in the solar system.

**DIRECTIONS** Read the following information. You may highlight important information, take notes, and/or use a post-it note strategy.

Venus and Serena were very interested in astronomy, especially Venus, since she was named after a planet and a goddess. It was even more fun to study for science since the current unit was about the solar system. Venus began by asking Serena, "What size is the Sun in comparison to Earth, and to the other stars?" Serena replied, "The Sun is more than a million times larger in volume than Earth, and is average in size compared to other stars."

Venus then asked Serena to "Compare the makeup of the inner planets to the makeup of the outer planets." Serena responded, "The inner planets are mostly solid and are made of rock. The outer planets are large balls of gas with small solid cores made of metal or rock." Venus asked, "What is similar about the way that planets, dwarf planets, asteroids, comets, and meteoroids move?" Serena answered "They all move through space, or some kind of orbit, around the sun."

Venus then drew the following picture of the solar system:



After which she asked, "Which number in the figure corresponds to the asteroid belt?" and "What characteristics of the asteroid belt is incorrectly suggested in the figure?" Serena replied, "Number 9 corresponds to the asteroid belt. The actual asteroid belt contains thousands of asteroids (not just five) that orbit the Sun in a circular orbit."

"Here's a question for you, is the model drawn to scale? Explain." Serena responded, "No, the Sun is much larger than the planets, and the planets' orbits are more spread out than is shown in the model." "Ok, then what body is represented by the object labeled 11 in the figure? Is the object visible from Earth? Why or why not?" Serena answered, "The object labeled 11 represents the Moon. The Moon is visible from Earth because it reflects light from the Sun."

Venus asked, "Which number in the figure corresponds to a dwarf planet and what is its name? Explain how dwarf planets differ from regular planets." Serena replied, "Number 2 corresponds to the dwarf planet Pluto, dwarf planets are smaller than regular planets." "One last question," Venus said, "why do you suppose scientists thought that Pluto was not an outer planet?" Serena responded, "The outer planets are gas giants and Pluto is a small, spherical, rocky body."

**DIRECTIONS** For each question, write your answer in the space provided.

1. What size is the Sun in comparison to Earth, and to the other stars?

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2. Compare the makeup of the inner planets to the makeup of the outer planets.

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3. What is similar about the way that planets, dwarf planets, asteroids, comets and meteoroids move?

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4. Which number in the figures corresponds to the asteroid belt? What characteristic of the asteroid belt is incorrectly suggested in the figure?

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5. Is the model of the solar system drawn to scale? Explain.

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6. What body is represented by the object labeled 11 in the figure? Is this object visible from Earth? Why or why not?

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7. Which number in the figure corresponds to a dwarf planet and what is its name? Explain how dwarf planets differ from regular planets.

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8. Why do you suppose scientists thought that Pluto was not an outer planet?

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9. Apply what you have learned from this scenario.

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## **Chapter 4: Conclusion**

The literature supports text dependent learning. A unifying theme is to capture the interest of students by relating to their lives outside of school. Context-based learning, puts the students in an environment usually outside the classroom but suitable for learning. Argumentation helps students support their findings. The literature shows that student learning improves by using these methods. Research states how important it is for students to know how to get needed information from their reading.

I took the textbook lessons which were so difficult for my seventh grade science students to read, and tried to make each of the twenty lessons more relevant to my students' lives. I created a fictional scenario for each lesson and placed fictional characters that the students could relate to and then carefully infused non-fictional scientific content into the discussion between each of the main characters. This was done in a Socratic way so that the same questions the students had to answer were answered in the storyline.

My project could be expanded and extended now that the formula has been created so that it can be applied to virtually any scientific content area and even to other disciplines where content is non-fiction and a dry read for students. Whether it's eighth grade science, or whatever science discipline, by introducing a fictional

scenario for students that relates to their life outside of school and then infusing non-fictional content is a sure-fire way to bridge the gap between school and their outside of school interests.

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