THE EFFECTIVENESS OF PRE- AND POST-TESTS DATA ON A SCIENCE TEACHERS' LESSON PLANNING

by

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DEDICATION

I'd like to dedicate this project to my ever supportive and reassuring husband, Levi. I would have never started this journey if it wasn't for his unwavering support and inspiration. He gave me the courage to pursue this lifelong dream, even though it meant being apart for over a year. I am so thankful for his continued efforts in supplying me coffee, snacks, and an ear for listening to all my crazy thoughts during this process.

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I want to also thank my family and close friends for constantly being there for me when I needed them the most during this process. Thanks to their constant support and uplifting attitudes, I always felt capable in completing every task. Even when I had to leave my teaching job and move overseas, they were all helpful in any way I needed, even if it was just someone to bounce ideas off. They all helped me to feel confident and pushed me to become not only a better student, but also reignite the focus in my teaching career.

Lastly, I would like to thank Dr. Cristin Nowak, Matt Bannon and the William Chrisman staff. Even though I had to leave the district sooner than expected, everyone was incredibly nice and supportive during this project. Dr. Nowak and Matt Bannon were an essential part in this project from approving the data usage, sending documents, and being helpful in any way possible. I am thankful to have had the opportunity to work at that school and experience exceptional leadership from an administration team.

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ABSTRACT

The purpose of this study was to investigate how using a pre- and post-test could be beneficial for students, the teacher, and the teacher's future planning in a high school science setting. The project used pre-existing data from the 2021-2022 school due to an overseas military relocation. For the procedure, students were given a pre-test prior to learning the material and then the outcomes were studied. This analysis provided topics where students struggled and areas where they succeeded, which aided the planning process for activities, assignments, and assessments for the unit. At the end of the unit, the students were given the same test as their post-test. This analysis provided data on where students succeeded and areas still needing improvement for future lesson planning purposes. The results from this investigation yielded a positive outcome for teaching strategies, lesson planning, and student growth success. Since pre-existing data was used, there are ways to enhance this project to make it better for both teacher and student, by implementing reflection sheets for the teacher and questionnaires for the students. Exploring this avenue for a more effective lesson planning technique has its pros and cons, but it was shown, from this investigation, that implementing a pre- and post-test strategy enhances the teacher evaluation of student needs for the curriculum and thusly improving student content knowledge.

CHAPTER ONE

INTRODUCTION & BACKGROUND

Context of the Study

No matter the subject matter, planning an engaging and effective lesson takes countless hours in and out of the classroom. Though, what are some key aspects when planning a lesson? How do teachers know what is the best method to teach the content? Is it from professional development or on-site training? Even with all of that, we need to know which topics have priority over others to be addressed while teaching. All these questions could be answered with a simple solution of proper training and administering a pre-test. In this context, the pre-test would be the same end-of-unit test that you would give as the summative assessment but given before the students have learned the material. A pre-test serves a multitude of purposes ranging from getting the students thinking about the upcoming topic to helping the teacher see what the students already know. The data from this test would show the teacher what preexisting knowledge students have, by allowing them to quickly move through this material, and focus more time on topics the students struggled with. Essentially, utilizing a pre-test would help a teacher plan more effectively.

The Independence School District in Independence, Missouri currently implements this testing regimen. The district has made unit exams for most content areas to administer pre- and post-tests. I have first-handedly seen the data and growth from pre- and post- unit tests. Their usage inspired me to explore this topic further when I realized that not all schools take advantage of this system. The amount of data and information you gain from these tests is incredible.

Teachers can develop lessons based around student need, focusing on topics and themes that they struggled with, then only reviewing topics they have already mastered.

During the research, I taught Earth science at two high schools, William Chrisman (WC) and Van Horn, with most of my day at WC. I was one of only two Earth science teachers at WC, so we worked closely with one another on lesson planning and looking at data. The district is categorized as Title I and has a wide range of socioeconomic and ethnic diversity, with over half the population qualifying for free and reduced lunch. The Earth science classrooms are a mixture of sophomores and seniors throughout, so there is a varied range of behavior, maturity, and motivation. Due to these extenuating circumstances, I needed to focus on where everyone was academically with specific topics based on the pre-test results. If I could get a baseline consensus on where students may be struggling or succeeding, I could better help everyone in my classroom.

Pre-tests are not the only tool that yield data on student comprehension for future lesson planning purposes. We could look at previous test scores in math and science to see what topics those students struggled with and where they succeeded. For example, a prior math exam could show a student struggled with reading tables and graphs. With this knowledge, you gain perspective of how in-depth to take a graphing lesson for the Hertzsprung-Russel diagram or tracking a hurricane's trajectory. These specific tests can show if students need to learn basic graphing protocol like labeling axes or how to maintain scale, which then guides the future lesson planning.

Additionally, you could use the data from the pre-test to tailor specific formative assessments for the unit. For example, if students struggled with knowing the geologic time

scale, you would then choose specific types of formative assessments to effectively help them learn the subject, like comparing and contrasting the Eras. Another idea would be to use the post-test data to plan lessons. This would be an effective tool in planning future lessons and give the teacher an idea of what the students did well on and where they still struggled. The teacher could gain insight into adjusting labs, projects, and types of formative assessments to either keep, adapt, or replace with a more effective assignment to better fit the student's needs. Essentially, there are plenty of benefits to utilizing both pre- and post-tests in the science classroom, but there are limitations facing teachers today in using these specific data.

Focus Question

My focus question was, What is the effectiveness of implementing pre- and post-test data usage to enhance a science teachers' lesson planning?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Data in the Classroom

According to the National Assessment of Educational Progress (2019), using data to increase overall performance and support students academically in the classroom has become more important than ever. Applying data to make effective changes is frequently discussed. The term data is defined by the Merriam-Webster Dictionary (2022) as the factual information such as measurements or statistics, used as a basis for reasoning, discussion, or calculation. What does that mean for the classroom? It would be to use the data from our students in some form of assessment to reason, understand, and discuss how well they performed.

Data has been explored and defined in the classroom by three specific types that can be organized into educational use, performance, and nonacademic data. Educational and performance data refers to the commonly known standards-based examinations, usually at the end of the semester per state or district requirements. Nonacademic data refers to classroom work, teacher-made assessments, and teacher observations of the student work. Many educators would argue that with nonacademic data results, they would try to either change the teaching methods or remain consistent. Though, most of this research on data in the classroom is focused on the English and mathematics courses because it is much easier to obtain data in a course that perpetually builds upon itself throughout a school year. Whereas in the science classroom, it is difficult to track any type of data when most units stand alone. Given this information, researchers have seen that the expansive nature of inquiry in science warrants more investigation

into how to perform, use, and implement data in the science classroom (Snodgrass et al., 2016; Snodgrass et al., 2019).

Even with the open and growing discussion of how teachers need to investigate data in the science classroom, there are limitations. The factors that inhibit teachers from using or collecting data to its full potential include district rules, ineffective building leadership, lack of collaboration with other teachers, deficiency in professional development, shortage of time, and overall teachers' attitudes towards data (Kerr et al., 2006; Mandinach & Gummer, 2016; Snodgrass et al., 2016; Snodgrass et al., 2019; Wayman et al., 2012). Professional development is key in helping teachers, but when talking about data usage in the classroom, there is a lack of in-depth content knowledge and application from these meetings. Without the proper training, teachers feel overwhelmed and discouraged (Mandinach & Gummer, 2016). In a study done by Hirsch and Emerick (2007), over 40,000 North Carolina teachers were surveyed on their working conditions, focusing on in-school planning time and personal planning time outside of the classroom. They found 51% of educators reported having less than three hours a week for planning or collaborative work, with 77% overall reported having less than five hours a week. With this lack of planning time given during school hours, 57% of teachers reported working at least five hours a week outside of contract hours and 29% stated they worked ten hours or more.

In some school districts, teachers are limited by what they can do in a school year because the ultimate goal is for students to perform well on the end-of-course exams. These districts speak excessively about the importance of data and its effectiveness but lack the proper training to fully explain how to utilize it in the classroom (Wayman et al., 2012). With this type of limitation, teachers do not have the time or resources to fully investigate how data could help

their classroom, resulting in a negative view on data, as it is seen as an extra duty (Wayman et al., 2012; Young, 2006). However, when a teacher is given proper and ample instruction on data and how to use it, there is an overall positive attitude towards data usage in the classroom (Wayman et al., 2012). Developing data in the classroom comes in different forms and variations. In the science classroom, data can be done through formative assessments, summative assessments, and administering pre-tests.

Useful Assessments

Throughout an educator's lifetime, the main types of assessment they will use, are formative and summative assessments. Another type of assessment a teacher may use is for program evaluation, which is any type of assessment to evaluate and examine the effectiveness of a program. Formative assessments vary from a quick muddiest point or a two-sentence exit ticket from the lesson, to drawing a concept map to connect ideas within a topic or a reflection on the topic. Additionally, it has been noted that using exit tickets as a quick formative assessment was a beneficial tool for teachers in planning, or changing, their plans for that day or even week (Snodgrass et al., 2016). These types of assessments can be a fast way to gauge whether the students understand the topic and also dig deeper into expanding their knowledge as well. Formative assessments are also thought of as the substantive part of student learning, as this is where the student will demonstrate their understanding while the teacher observes (Ateh, 2015). It has also been noted, that when teachers fully utilize formative assessments effectively, student achievement was higher than when not used (Black & William, 1998). Summative assessments are the traditional end of unit exam or a final project for the unit. Simply administering these tasks to students is not enough, as teachers must understand the reasoning

behind using the specific assessments in the unit and analyze the outcomes to know the effectiveness of the assessment. This is vital for the overall influence (Izci et al., 2020).

For the assessments to be successful and create high student achievement, there are a few criterion educators should follow. For formative assessments to be prosperous, both the student and teacher need to understand the reasoning behind each given assessment and know the common end goal. This could be for the teacher to gain insight for future lessons or understand what the students know. Students constantly inquire as to why they need to learn a particular concept, by explaining the purpose and end goal, students would understand the value more and buy in to the task. One way to make formative assessment highly effective is to ensure that both students and teachers understand the learning goals. Student understanding can be determined by engaging in self-reflection, peer assessment, self-assessment, providing useful feedback, and using all of it to learn strategies for the next unit. When the students are open-minded and willing to put in the work through the various assessments, like self-reflection, and the teachers fully analyze the outcomes, then formative assessment is at its highest efficacy (Black & William, 1998; Gotwals & Cisterna, 2022).

Using Data from Assessments to Plan

There are numerous assessments that can help educators develop a successful lesson plan and promote student success. The focus will be on using data from various formative assessments and pre- and post-test scores. Using these various methods of data will, in turn, help a science teacher create effective future lessons plans. By utilizing a variety of assessments and focusing them on scientific content and practices, the teachers will gain more useful data from their students (Black & William, 1998; Snodgrass et al., 2016). Examining data from

assessments highlights how teaching is an ever-evolving process where the educators become proficient in their craft by not repeating old routines and adjust accordingly to the needs of their students (Young, 2006). Once we recognize this fact in education, the more beneficial plans we can make for our students to be productive. In addition, research has shown that using data-based decision making regarding future lesson plans has a positive impact on student achievement in the class, from their overall attitude and success (Kerr et al., 2006).

One way to plan future lessons using data, is to look at students' past assessment scores from state or district administered assessments. Science teachers could look at a student's previous math and reading state assessment scores to gather an idea of their struggles that could correlate to the science classroom (Snodgrass et al., 2016). Educators could also use those scores to determine student's strengths in math and English to plan more effective lessons where students could be successful or even push them to succeed in higher-order thinking activities. In all science courses, math and reading are an essential part to understanding concepts, so looking into past scores for future lessons is a great way to create effective plans. Some other ways to track data in a science classroom include performing a vocabulary assessment like a pre- and post- quiz, using exit tickets at the end of a lesson to capture any misconceptions, or doing a quick check of understanding using whiteboards (Nowak, 2022).

Another way is to administer a pre- and post-test for each unit. The teacher would create the unit test beforehand, give that test at the beginning of the unit and then use the same test at the end to analyze student growth. The pre-test data guides lesson planning as you would see which topics students struggle in and which topics they already know. For the post-test data, you would analyze which topics students improved upon, where they excelled, and where they still

struggle. This allows teachers to develop successful future planning and instruction. When teachers give any form of assessment and look at the results, teachers will alter their lesson plans. Research has shown that most teachers will differentiate their instruction for any type of remediation, from re-teaching concepts to changing the pace of teaching the concepts when they collect data on an assessment (Hoover & Abrams, 2013). Plus, if teachers are supported by staff and leadership, the buy-in to use and analyze data are much higher (Wayman et al., 2012). It is fundamental that teachers receive sufficient support from leadership and planning time to prepare, perform, collect, and analyze data from these assessments to create more effective lesson plans.

CHAPTER THREE

METHODOLOGY

Demographics

This study investigated the effectiveness of using pre- and post-tests in a science classroom with regards to a teachers' lesson planning. This project used pre-existing data from the 2021-2022 school year at William Chrisman High School in Independence, Missouri. At the time, I taught at two different high schools within the district, and the classrooms used were from WC which consisted of four classrooms and approximately 90 students. The climate of the classes ranged from enthusiastic and ready to learn, to uninterested and lacking motivation. Within WC, the student population had around 1,400 students in 9th to 12th grade during that school year (Becker, M). The demographics consisted of 57.5% Caucasian, 15.3% Hispanic, 13.5% African American, 10.3% of two races of more, 1.3% Asian, 1.2% Pacific Islander, and 1.0% American Indian students (U.S. News, 2022). Earth science is taken by 10th through 12th grade students as an option for their science credit requirements.

Study Design

For this research of using pre-existing data, I had one data source to investigate. The reason behind this was moving overseas for military obligations and being unable to have a classroom for the following school year. Accordingly, the data collection instrument used was the district provided units' summative assessments for the five units explored in an Earth Science curriculum. The five units examined were astronomy, Earth's history, plate tectonics with

volcanism and earthquakes, geology with weathering and erosion, and meteorology with climate change. I used the same unit test for the pre- and post-test treatment.

The students took the tests on a Chromebook application called Illuminate, which provided me with all the data. The students were given the full 90-minute block class period to complete each test during. After each pre-test had been taken, I began the lesson with either a misconception probe, inquiry or phenomena driven activity, or class discussion over the topic. Once I had collected all the pre-test data, I created or found specific formative assessments on concepts where students struggled and needed more support. When a six-to-ten-week unit was completed, the students took their post-test as their summative grade. After I had collected and saved the data, I made notes on which concepts the students still struggled with and topics the students excelled in for future lesson planning purposes. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Data Collection and Analysis Strategies

Each test had 30 multiple-choice questions, which ranged from low to high level questioning. The questions varied from defining a vocabulary term to analyzing and interpreting a given graph, table, or diagram. Within each test, every question was tied to a specific Missouri standard. The results from the Illuminate website provided details about each question and associated standards. The results also denoted students with individualized education plans and 504 modifications and how they performed. The pre-tests were given before each unit, though within the school year, students moved in and out of the district, and it was difficult to get those new students to take the pre-test for data purposes. The growth data collected from Illuminate

only calculated those students who took both the pre- and post-tests, with a varied number of students for each unit test.

Once all the post-test scores were received, I compiled and compared the data from both the pre- and post-tests. I conducted a paired t-test to compare the results for each test and calculated the mean, median, and mode for analysis. A normalized gain test was also performed for both test results. The normalized gain was calculated to determine differences in student knowledge. Normalized gains of less than 0.3 percent were considered low, gains 0.3 to 0.7 were considered a medium gain and normalized gains greater than 0.7 were considered high (Hake, 1998). For each unit test, three to five Missouri standards were tested, out of the possible 19 Earth and Space Science standards, and some standards were used with more than one question (Appendix G). I investigated the details of each question, its associated standard, growth in student scores, and overall percentage of how well the students did for both tests. After analyzing the data aspects for both pre- and post-test, I reflected on my lesson planning and what I would alter for lessons. Specific strategies I used for my lessons based off pre-test scores were background knowledge pre-checks, labs with a feedback form, and reflection forms (Appendix H-J). Also, I created a teacher journal and student survey forms to be utilized as an improvement to this study (Appendix K-L). A data triangulation matrix was created to summarize the question of the study and data source (Table 1).

Table 1. Data Triangulation Matrix.

Focus Question	Data Source 1
What is the effectiveness of implementing pre- and post-test data usage to enhance a science teachers' lesson planning?	Pre- and Post-Tests

DATA ANALYSIS

Results

The results of the Unit 1 Astronomy tests yielded an overall increase of scores. The Astronomy pre-test lowest score was a 5, high score of 87, with a range of 82 points. The mean for this test was 37, median and mode were both 31 with a standard deviation of 18. After the pre-test, I had a class discussion with each class to see their thoughts of the material and the most common response from students were that they knew about the planets and main details, but they didn't know the specifics about the stars. The post-test lowest score was a 31, high score of 100, with a range of 69. The mean score for this was 71, mode was 77, and median was 74, with a standard deviation of 17 (Figure 1). The normalized gain of averages for these tests was a gain of 0.54, which is considered a medium gain (Hake, 1998). Results of a paired t-test performed on the pre- and post-test scores showed there was a significant difference between scores ($p<0.05$) with a p-value of 0.00. This states that we can reject the null hypothesis and support there is significance.

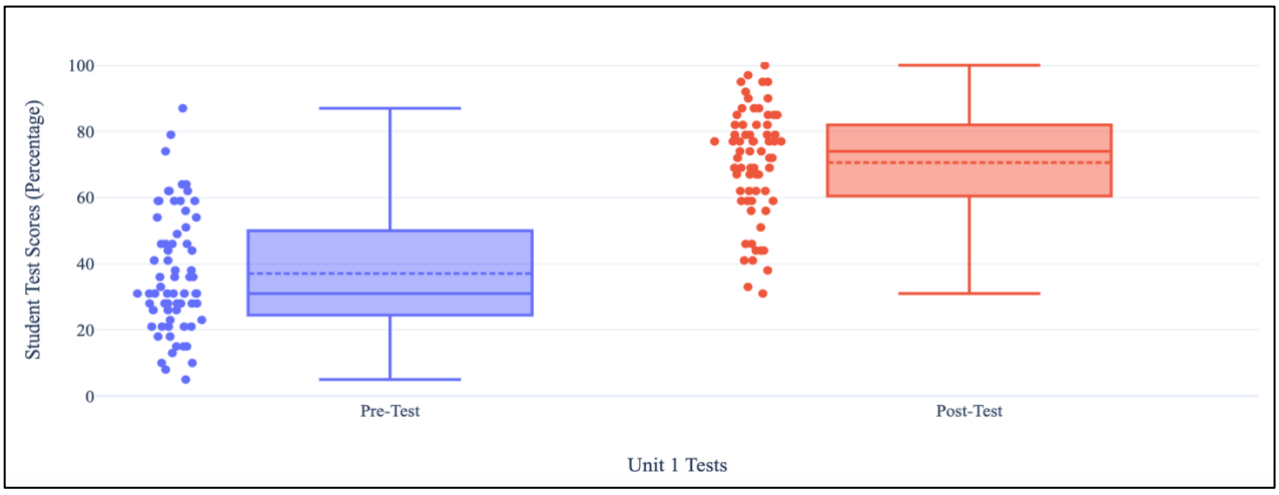

Figure 1. Astronomy student test scores, (*N*=68).

Within each test, there are specific Missouri science standards tied to every question, with some questions having more than one associated. For each test, there was positive growth in understanding the topics. Astronomy had five learning standards and all of them increased. The learning standards for this test were Earth and Space Science (ESS) category 1, which involved Earth's place in the universe. ESS1.A.1 had six questions and increased by 88%, ESS1.A.2 had three questions and increased by 29%, ESS1.A.3 had two questions and increased by 71%, ESS1.B.1 had 19 questions and increased by 124%, and ESS1.C.2 had one question and increased by 40% (Figure 2).

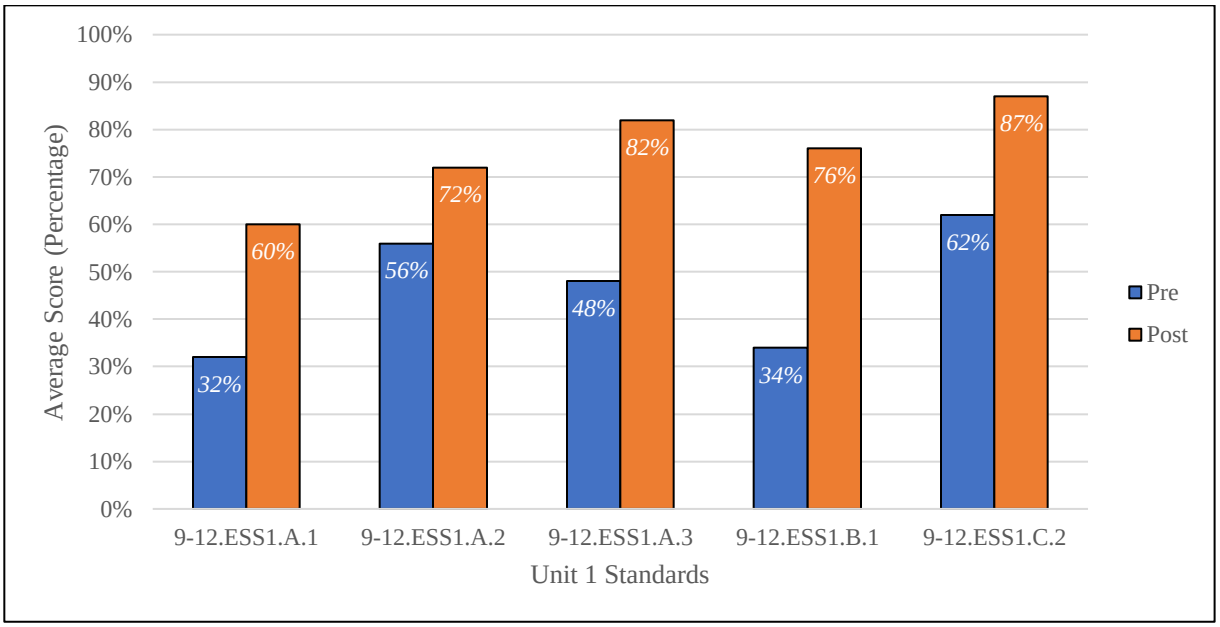

Figure 2. Astronomy science standards between pre- and post-tests, (*N*=68). *Note*. 9-12 ESS1.A.1 states to develop a model based on evidence to illustrate the life span of the Sun and the role of nuclear fusion in the Sun's core to release energy in the form of radiation, 9-12 ESS1.A.2 states to construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe, 9-12 ESS1.A.3 states to communicate scientific ideas about the way stars, over their life cycle, produce elements, 9-12 ESS1.B.1 states to use Kepler's Law to predict the motion of orbiting objects in the solar system, and 9-12 ESS1.C.2 states to apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

The Unit 2 Earth's History pre-test had a low score of 6, high score of 64, with a range of 58. The mean was 37, mode 39, and the median was 38, with a standard deviation of 14. After this test, I had a class discussion about how the students felt on this topic. Over half of the students in each class said they recognized terms like Jurassic and Triassic but had no clue about the laws, dating of rocks, and layers of everything. The post-test had a low score of 11, high score of 92, and a range of 81. The mean was 69, mode was 75, and the median was 71, with a standard deviation of 14 (Figure 3). The normalized gain of averages was a gain 0.51, which is considered a medium gain. The paired t-test performed resulted in a p value of 0.00 which means we can reject the null hypothesis and say there is significance in these different test scores ($p<0.05$).

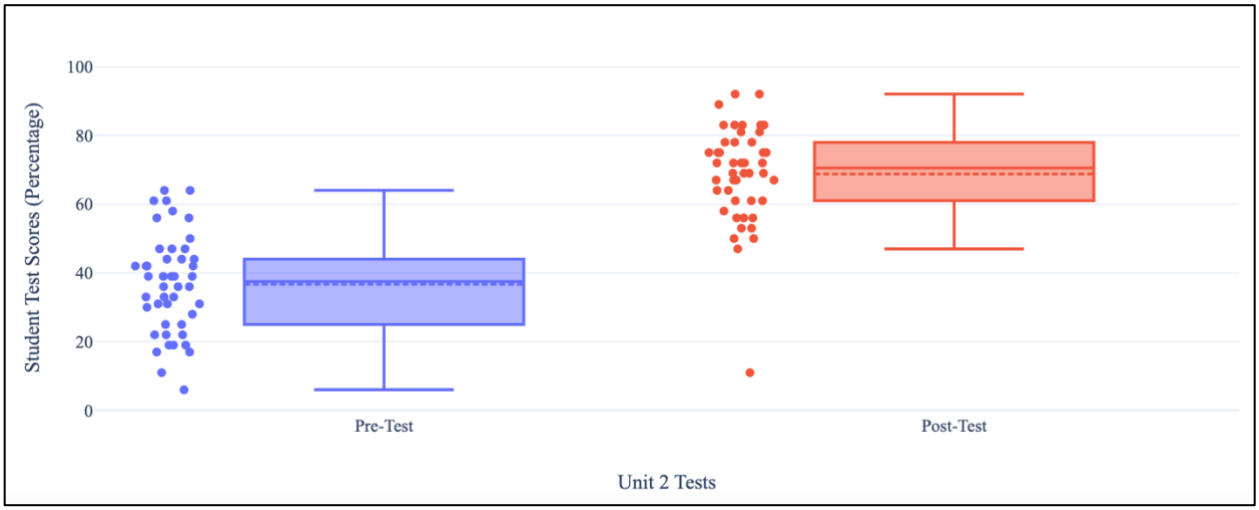

Figure 3. Earth's History student test scores, (*N*=46).

For the Earth's History test, there were three science standards connected to this exam and showed improvement. This test also had ESS1 standards connected as well as category 2 which involved Earth's systems, specifically biogeology. The standards ESS1.C.1 had six

questions and increased by 79%, ESS1.C.2 had 11 questions and increased by 81%, and ESS2.E.1 had 13 questions and increased by 73% (Figure 4).

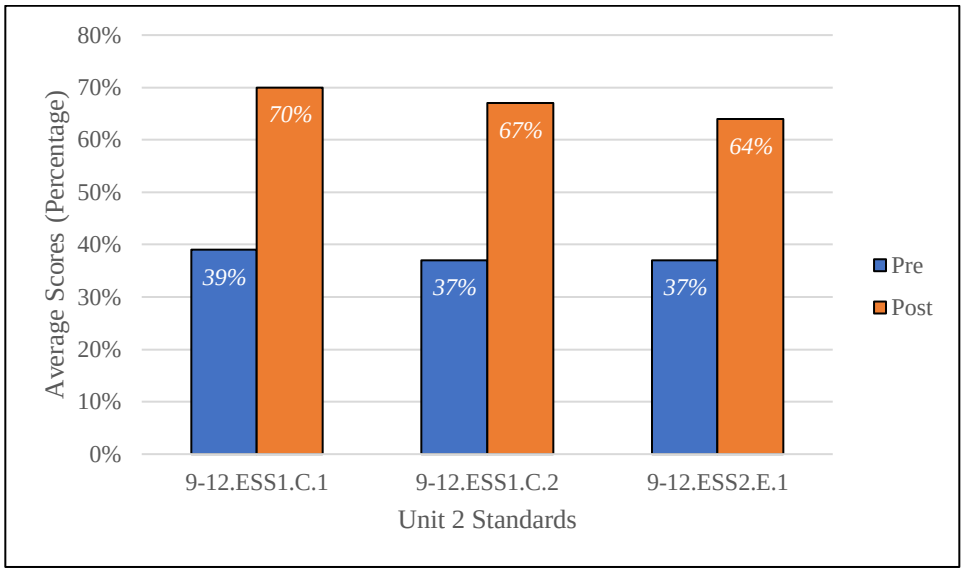

Figure 4. Earth's History science standards between pre- and post-tests, (*N*=46). *Note*. 9-12 ESS1.C.1 states to evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor, 9-12 ESS1.C.2 states to apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history, and 9-12 ESS2.E.1 states to construct an argument based on evidence about the simultaneous coevolution of Earth's Systems and life on Earth.

The Unit 3 Plate Tectonics pre-test had a low score of 16, high score of 54, with a range of 38. The mean for this was 34, mode was 32, and the median was 34, with a standard deviation of nine. After this test, the class discussion was lively in students commenting on how they did not know a lot about this topic. The common response was that they didn't know all about different ways volcanoes can form and confusion about the different types of boundaries. The post-test had a low score of 38, high score of 84, with a range of 46. The mean was 59, mode 54, and median was 57, with a standard deviation of 12 (Figure 5). The normalized gain of averages

resulted in 0.38, which is considered a medium gain. The paired t-test performed did result in a p value of 0.00, so we can say there is significance in these different test scores ($p<0.05$).



Figure 5. Plate Tectonics student test scores, (*N*=38).

The Plate Tectonics test had four science standards associated and showed growth. This test had one standard for Earth's place in the universe and the rest with Earth's systems, more specifically Earth materials. ESS1.C.1 had nine questions and increased by 39%, ESS2.A.1 had 14 questions and increased by 61%, ESS2.A.2 had four questions and increased by 135%, and ESS2.A.3 had eight questions and increased by 88% (Figure 6).

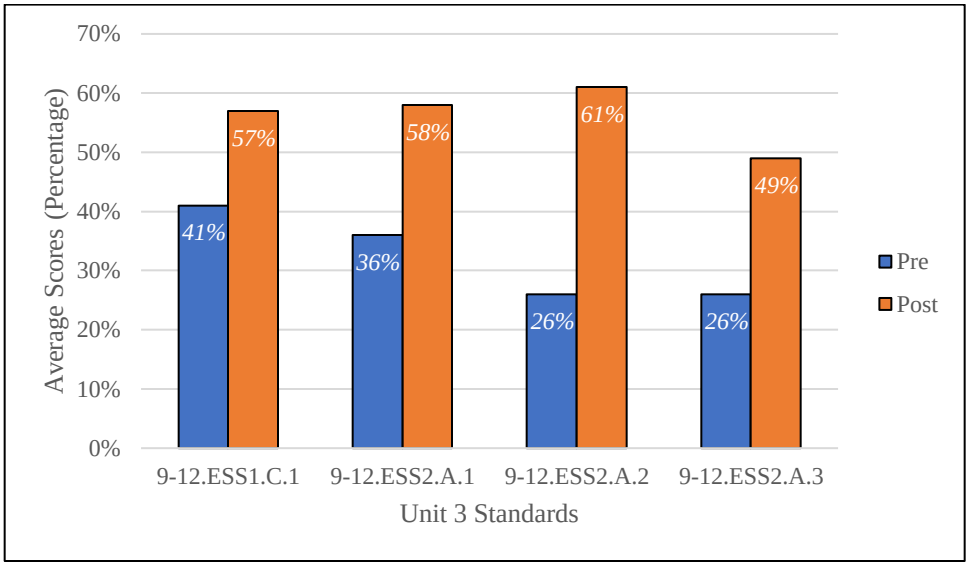

Figure 6. Plate Tectonics science standards for both pre- and post-tests, (*N*=38). *Note*. 9-12 ESS1.C.1 states to evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor, 9-12 ESS2.A.1 states to develop a model to illustrate how Earth's interior and surface processes, 9-12 ESS2.A.2 states to analyze geoscientific data to make the claim that one change to Earth's surface can create changes to other Earth Systems, and 9-12 ESS2.A.3 states to develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

The Unit 4 Geology pre-test had a low score of 18, high score of 62, with its range of 44. The mean for this test was 43, mode of 33, and median of 41, with a standard deviation of 12. After this test, the class discussion had a consensus that they knew about rocks, weathering, and erosion, but they didn't know the specific types of rocks in detail. The post-test had a low score of 49, high score of 92, with a range of 43. The mean for this test was 74, mode of 69, and median of 72, with a standard deviation of 11 (Figure 7). The normalized gain of averages for these two tests was 0.54, which is a medium gain. The paired t-test performed resulted in a p-value of 0.00 and we can conclude there is significance amongst these different test scores ($p<0.05$).

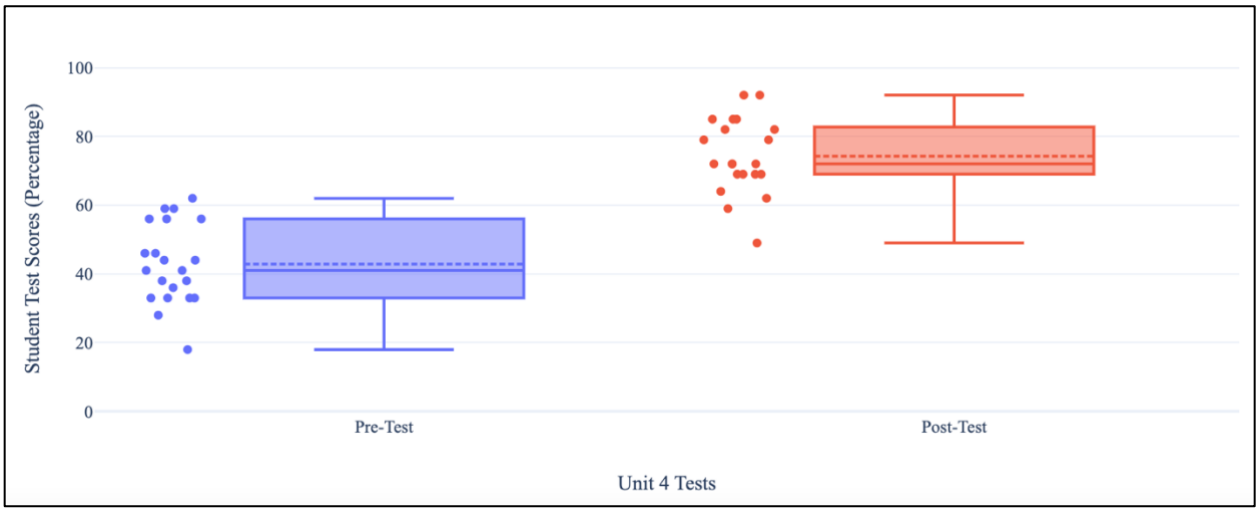

Figure 7. Geology student test scores, (*N*=21).

The Geology test had five science standards connected and saw an increase. One standard involved Earth's system specifically the role of water, and the rest with category 3 which included Earth and human activity, particularly looking at natural resources. The standards ESS2.C.1 had six questions and increased by 73%, ESS3.A.1 had nine questions and increased by 74%, ESS3.A.2 had 11 questions and increased by 71%, ESS3.C.1 had three questions and increased by 36%, and ESS3.C.2 had one question and increased by 300% (Figure 8).

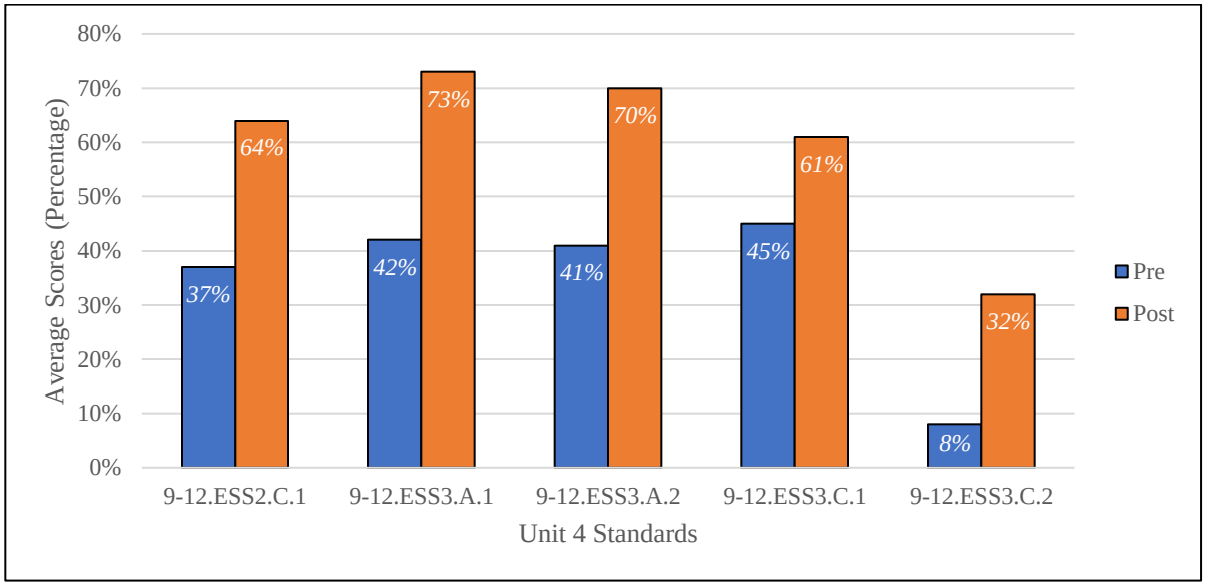

Figure 8. Geology science standards for both pre- and post-tests, (*N*=21). *Note*. 9-12 ESS2.C.1 states to plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes, 9-12 ESS3.A.1 states to construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity, 9-12 ESS3.A.2 states to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on economic, social, and environmental cost-benefit ratios, 9-12 ESS3.C.1 states to create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity, and 9-12 ESS3.C.2 states to evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and or biodiversity of the ecosystem as well as prevent their recurrences.

Lastly, Unit 5 Meteorology pre-test had a low score of 19, high score of 67, with the range of 48. The mean score was 48, mode was 44, and the median was 47, with a standard deviation of 11. After this test, most students felt familiar with weather and climate concepts but were confused on the specific terminology. The post-test had a low score 35, high score of 93, with a range of 58. The mean was 76, mode was 74, and median of 77, with a standard deviation of 12 (Figure 9). The normalized gain of averages for these exams was 0.54, which is a medium gain. The paired t-test concluded a p-value of 0.00, which means we can again reject the null hypothesis and support there is significance between these pre- and post-test scores ($p<0.05$).

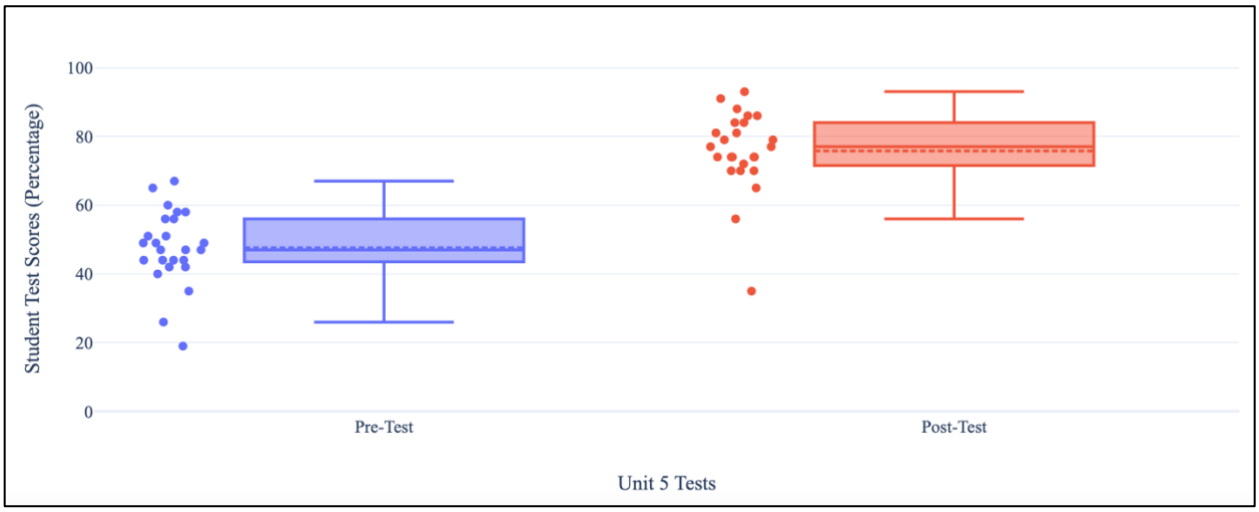

Figure 9. Unit 5 Meteorology student test scores, (*N*=25).

The Meteorology tests had three science standards connected and saw an overall increase. The standards ESS2.D.1 had 12 questions and increased by 80%, ESS3.D.1 had 14 questions and increased by 43%, and ESS3.D.2 had seven questions and increased by 43% (Figure 10).

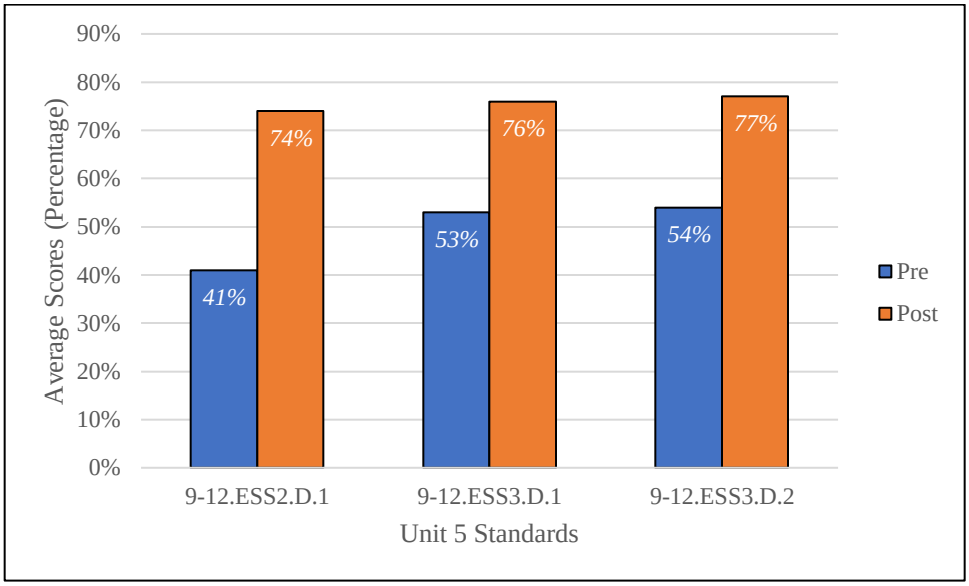

Figure 10. Unit 5 Meteorology science standards for both pre- and post-tests, (*N*=25). *Note*. 9-12 ESS2.D.1 states to develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, 9-12 ESS3.D.1 states to analyze geoscientific data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems, and 9-12 ESS3.D.2 states to predict how human activity affects the relationships between Earth Systems in both positive and negative ways.

Overall, there was growth between the pre- and post-test scores throughout the Earth science curriculum. The Astronomy tests yielded an increase in scores of 34%, Earth's History tests had an 32% increase, Plate Tectonics with earthquakes and volcanoes tests increased by 25%, Geology with weathering and erosion tests increased by 31%, and Meteorology with climate change tests increased by 28% (Figure 11).

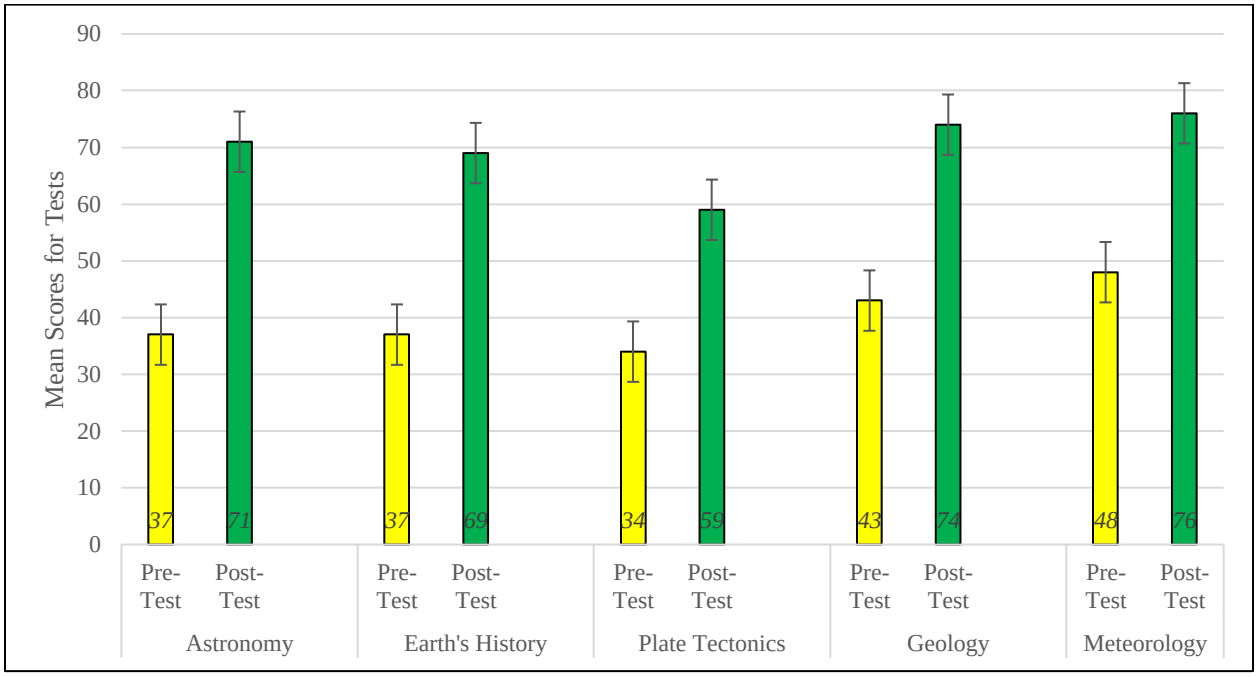

Figure 11. Mean score differences between all five-unit tests, (*N*=68 for Astronomy, *N*=46 for Earth's History, *N*=38 for Plate Tectonics, *N*=21 for Geology, and *N*=25 for Meteorology).

Missouri performance standards are based on the student's post-test score and are as follows: Below Expectations was 0-59%, Emerging was 60-70%, Approaching was 71-79%, and Meets (which is also considered Mastery) was 80-100% score. The goal for each post-test was to have more students mastering the material and less reaching below the expectations. It was also acceptable for students to reach the Approaching standard as well. The Geology test was the only one to have more students in the meet category. The Plate Tectonics test was the only one where 58% of students were below expectations (Figure 12).

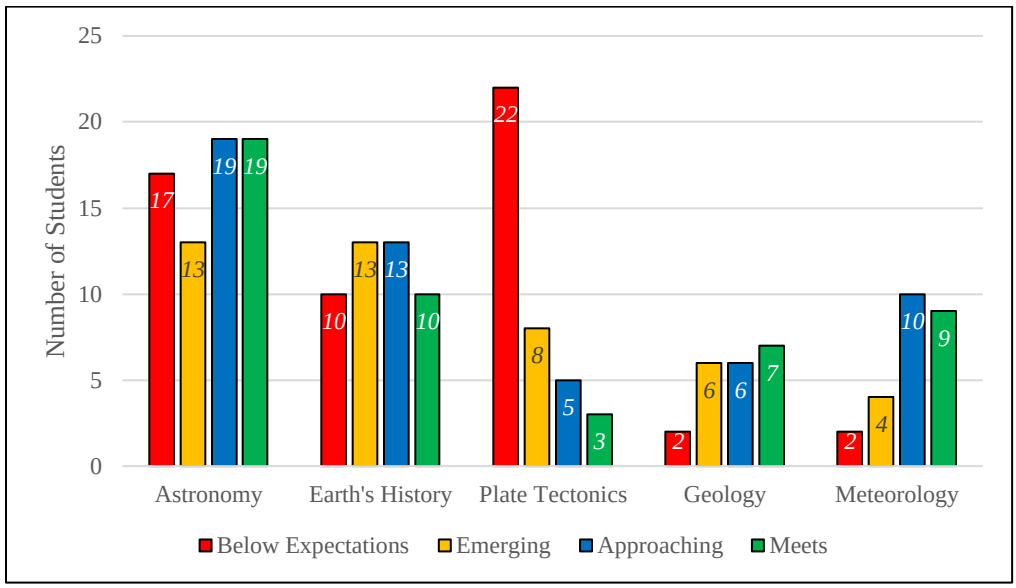

Figure 12. Performance based standards for each post-test, (*N*=68 for Astronomy, *N*=46 for Earth's History, *N*=38 for Plate Tectonics, *N*=21 for Geology, and *N*=25 for Meteorology).

CHAPTER FIVE

CLAIM, EVIDENCE, AND REASONING

Claims From the Study

This action research investigated the usage of pre- and post-test data as a tool for a science teacher's lesson planning endeavors. Even though some tests scored lower than others and the overall class sizes were not the same, there was a strong claim and positive correlation of this being an effective planning strategy. This type of data-based lesson planning is what Kerr (2006) talked about when creating high student achievement in the classroom. Whether the use of pre- and post-test or formative assessment data, using data to drive lesson planning was effective in the classroom. As a result of this, the following claims are there was an increase in student scores from pre- to post-test, increase in student growth based on performance and confidence, and an increase in student understanding based on learning standards. The analysis between the pre- and post-tests produced a strong correlation of student growth over all five units of tests. The comparison between tests had a varied number of students who took both, and even with this discrepancy, there was progression. Each test showed positive growth in terms of scores and Missouri learning standards due to using data to drive my lesson planning.

When I had all pre-test data, I analyzed which Missouri learning standards were the lowest and the associated questions to begin my lesson planning. I also looked at specific questions that scored the lowest regardless of standard to create a complete idea of where students struggled. I had either class discussions or one-on-one discussions with students on how they felt about the unit material. The responses ranged from not having a clue to remembering

some topics from previous years. Based on these findings, I would then create or find specific formative assessments that would match those topics to best help the students learn.

Looking at the Astronomy pre-test scores, students struggled the most with Missouri standard questions about planet details, order, composition, and specifics about what stars are made of and their classification (ESS1.A.1 and ESS1.B.1). Based on these results, I used a multitude of formative assessments to improve their learning of those topics. To gather more understanding of what my students knew and did not know about planets, I performed a background knowledge pre-check at the start of class. This pre-check enabled me to dig deeper in how I asked students questions before learning the topic, from utilizing prior schema questions to introducing new terminology and if students could figure out what it meant. Similarly, it allowed for great class discussions after everyone had completed the pre-check.

From the pre-test standards and questions relating to specific details about the stars, I chose a Hertzsprung-Russel diagram lab to encompass vocabulary and application once the students learned more about the stars. After this activity was complete, I gave my students a lesson feedback form to analyze how they felt about this lab. Using this type of lab activity to incorporate essential vocabulary and applying their knowledge, and then having students fill out the feedback form, was a great tool in my lesson planning. I was able to receive constructive comments, good and bad, on how to improve this lesson for the next time. Another formative assessment I used for stars concept was a Sun and Stars Vocabulary Review and student reflection form. This reflection form really made the students think about their performance, reflect on this activity, and to help them to know what they needed to work on for the future. Using self-reflection, whether teacher or student, is an essential part in understanding student

needs and future growth (Black & William, 1998; Gotwals & Cisterna, 2022). All of this supports the increase in those two Missouri standards, which involve students developing a model about the the Sun and the role of nuclear fusion (ESS1.A.1) and students being able to apply Kepler's Law to predict the motion of orbiting objects in the solar system (ESS1.B.1).

These types of assessments I chose based on the Astronomy pre-test helped me to plan all future lessons for the following units. I had a greater understanding of how to analyze the pre-test data, with looking at the low scoring standards and questions, and creating a good idea of what type of formative assessments to try. Based on the literature, using formative assessments is a vital part in helping students understand concepts and guide them to apply that knowledge (Snodgrass et al., 2016). So, I kept using, and especially liked, the background knowledge pre-check type of assessment because it gave me more understanding of what the student comprehension. I was able to manipulate the questions that best fit my needs so I could better serve my students. I will admit, using the pre-check did cut into my planning period since I would change notes or other activities, but they still showed to be useful. Also, using a variety of teacher feedback forms, class discussions, and student reflections helped the planning process. I was able to get real-time feedback on what the students liked, what helped them, and what did not in that moment. I was able to adjust accordingly for the next lab or activity. Though, those reflections and feedback forms were the most useful in planning future lessons for the following school year, they were highly effective in getting to know my students and what they needed.

Value and Impact of Study

Overall, I feel this investigation was a success not only for my students but also for myself. This was my first time teaching an Earth science course, so I was not super familiar with

all the topics, and I was apprehensive on how to approach the wide variety of content. This action-research helped me to have more confidence in myself, my teaching abilities, and my tenacity to change the plan to better help my students learn the material. This study gave me a greater understanding on how to create a more effective lesson plan too. I was able to see exactly what topics students struggled with, therefore I could focus my notes and activities to better suit them. Plus, I got to see information they already knew and would not have to spend as much time on a specific concept. I feel my students benefited from this more personal approach. I felt I was able to have a better understanding of their needs, how they learn, and give them a better learning experience overall. I also know, based on the student reflections and surveys, that they appreciated my check-ins with them on how they felt about the activity and if it was beneficial. Even when given the opportunity to give anonymous feedback, my students were still cordial, gave honest reviews, and gave me insight on how to improve. This simple act gave my students the knowledge that I did care about their learning progress and how I wanted to do better for them. This aspect helped with having a greater rapport with my students.

So, as this was my first year teaching this topic and also completing this extensive lesson planning endeavor, I know it took quite a bit of time to analyze the data and plan accordingly. I felt extremely lucky to have had the support from the administration. We were given professional development days to extensively go through the data and work with our departments. This was an integral part of how I was able to analyze data to better plan lessons. Teachers need to be supported in many ways so we can better ourselves and in turn better our students. Whether it is professional development days dedicated to data analysis or extra planning time, once teachers are given time, they can accomplish anything. I firmly believe this

extra work will make future lesson planning easier, especially with post-test data, and help teachers in all areas create the most effective lessons for student success.

Improvements for Study

Since I used pre-existing data, I was limited in my resources used and information gathered. I do feel this action research was a huge success and showed a positive, strong correlation between using pre- and post-test data to create an effective lesson plan, there are still ways to improve upon this idea. A key improvement would be the student buy-in to take the pre-test. I feel I got max participation in the unit 1 pre-test because it was the beginning of the school year and everyone was willing to put in the work. After that, the initiative to take this non-graded and non-risk pre-test faded each time. An idea to get more students to take the pre-test would be to offer some kind of incentive, whether it is extra points on an assignment, a coupon for a freebie on select assignments, choice of candy, or a prize afterwards.

Another way to improve this study would be to implement reflection forms and surveys. Throughout this MSSE journey, reflection has been an enormous takeaway for me as a teacher. I whole-heartedly believe in the power of reflecting on one's performance to better themselves. I think implementing a teacher reflection journal for both pre- and post-tests will better help the teacher to understand and process the results. I also feel giving the students a reflection survey for both pre- and post-test performance will help them to evaluate themselves and to hopefully do better next time. I do know that time is a highly valuable aspect in the teaching profession, so taking the time to implement these changes and analyze the data would be tough to accomplish. Even with some obstacles to overcome, I feel when these changes are implemented, in any content area, the teacher will feel more confident in themselves and create a better lesson.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION

From: NoReply@TOPAZTI.net <NoReply@TOPAZTI.net>

Date: Monday, December 5, 2022 at 11:42 AM

To: Graves, John

<graves@montana.edu>, almyers188@gmail.com <almyers188@gmail.com>,

Beiswanger, Kelly <kelly.beiswanger@montana.edu>

Subject: IRB Protocol #2022-443-EXEMPT APPROVED

External Sender

Hello Myers, Ashley L.,

Your protocol was reviewed by the IRB and has been approved.

PI: Myers, Ashley L.

Approval Date: 12/5/2022

Title: The Effectiveness of Utilizing Pre-and Post-Tests Data on a Science Teachers'

Lesson Planning

Protocol #: 2022-443-EXEMPT

Review Type: Exempt Review

Expiration Date: 12/5/2027

APPENDIX B

UNIT 1 ASTRONOMY TEST

Earth Science Unit 1: Space 21-22 (Teacher Edition) Assessment ID: ib.2830253

Directions: Answer the following question(s).

1 All are required to be considered a planet except...

A. Must have enough gravity to form a sphere shape
B. Must travel around a star
C. Must have a clear orbit
D. Must have a moon

Master ID:	3883019 Revision:	1
Correct:	D	
Standards:		
9-12.ESS1.B.1		

2 The outer planets are made mostly of what substances?

A. Silicate minerals
B. Water and carbon dioxide
C. Hydrogen and helium
D. Water ice and sulfur

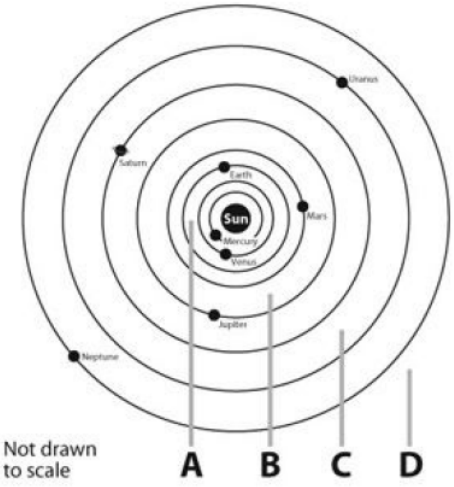
Master ID:	3883011 Revision:	1
Correct:	C	
Standards:		
9-12.ESS1.B.1		

3 Which of the following are terrestrial planets? **Select all that apply.**

A. Pluto
B. Neptune
C. Uranus
D. Jupiter
E. Mars
F. Earth
G. Venus
H. Mercury

Master ID:	3883004 Revision:	2
Correct:	EFGH	
Standards:		
9-12.ESS1.B.1		

4 Which correctly identifies the location of the asteroid belt?

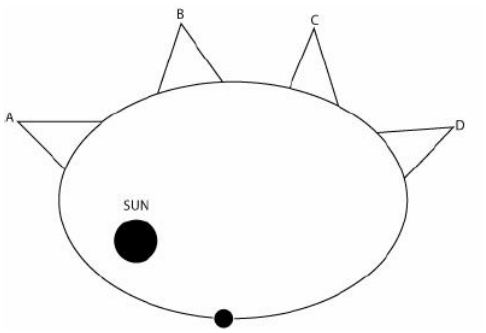


A. A
B. B
C. C
D. D

Master ID:	3882990 Revision:	1
Correct:	B	
Standards:		
9-12.ESS1.B.1		

Directions: Answer the following question(s).

5 At which labeled interval of its orbit would the planet move with the greatest velocity?



A. A
B. B
C. C
D. D

Master ID:	3882976 Revision:	1
Correct:	A	
Standards:		
9-12.ESS1.B.1		

6 If the following line represents unshifted light from a star, which of these shows how light wave would change if the star started moving away from the observer?



unshifted light

A. 

B. 

C.

D. 

Master ID:	3882963 Revision:	2
Correct:	A	
Standards:		
9-12.ESS1.A.2		

7 What layer of the Sun transfers energy in a cicular motion like boiling water?

A. Convection zone
B. Corona
C. Core
D. Radiation zone

Master ID:	3882957 Revision:	2
Correct:	A	
Standards:		
9-12.ESS1.A.1		

Directions: Answer the following question(s).

8 Where does nuclear fusion take place in a star?

A. Chromosphere
B. Corona
C. Photosphere
D. Core

Master ID:	3882952 Revision:	1
Correct:	D	
Standards:		
9-12.ESS1.A.1		

9 When looking at an H-R Diagram, what stage is the star moving into when nuclear fusion begins?

A. Planetary Nebula
B. Protostar
C. Main sequence
D. Super nova

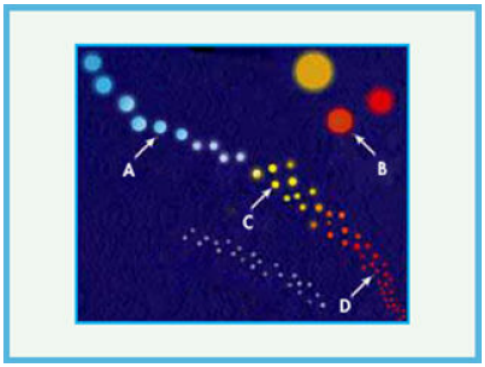
Master ID:	3882950 Revision:	2
Correct:	C	
Standards:		
9-12.ESS1.A.1		

10 Which correctly lists the objects in order of decreasing mass?

A. Solar System, Jupiter, Earth, Sun
B. Solar System, Jupiter, Sun, Earth
C. Solar System, Sun, Jupiter, Earth
D. Sun, Solar System, Jupiter, Earth

Master ID:	3882928 Revision:	1
Correct:	C	
Standards:		
9-12.ESS1.A.2		

11



Stars in which part of the diagram burn the hottest?

A. A
B. B
C. C
D. D

Master ID:	3882926 Revision:	1
Correct:	A	
Standards:		
9-12.ESS1.A.1		

12 What force draws the matter in an interstellar cloud together to form a star?

A. electric
B. magnetism
C. friction
D. gravity

Master ID:	3882919 Revision:	1
Correct:	D	
Standards:		
9-12.ESS1.A.2		
9-12.ESS1.A.3		

Continue: Turn to the next page.

Directions: Answer the following question(s).

13 Most of the light emitted by the Sun comes from the _____.

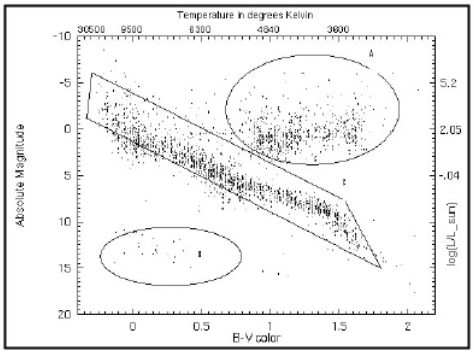
A. chromosphere
B. corona
C. photosphere
D. prominence

Master ID:	3882906 Revision:	1
Correct:	C	
Standards:		
9-12.ESS1.A.1		

14 What two gas giants appear blue because of the methane in their atmosphere?

A. Jupiter and Saturn
B. Saturn and Uranus
C. Neptune and Uranus
D. Jupiter and Neptune

Master ID:	3882881 Revision:	1
Correct:	C	
Standards:		
9-12.ESS1.C.2		

15 

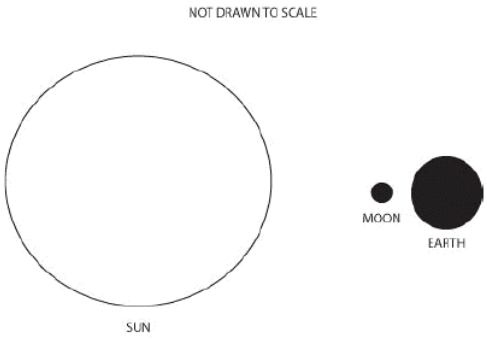
Where on the **H-R** diagram are the main sequence stars?

A. A
B. B
C. C
D. None of the above

Master ID:	3882862 Revision:	1
Correct:	C	
Standards:		
9-12.ESS1.A.3		

Directions: Answer the following question(s).

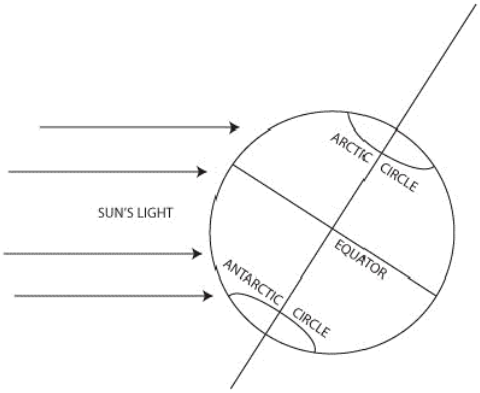
16 Which phase is the Moon in when the Earth, Sun, and Moon are in the positions shown in the diagram?



A. New moon
B. Full moon
C. Waxing Crescent
D. Waning Gibbous

Master ID:	3880503 Revision:	2
Correct:	A	
Standards:		
9-12.ESS1.B.1		

17 In the northern hemisphere, what day is represented by this diagram?



A. vernal (spring) equinox
B. summer solstice
C. autumnal (fall) equinox
D. winter solstice

Master ID:	3880496 Revision:	2
Correct:	D	
Standards:		
9-12.ESS1.B.1		

18 A lunar eclipse occurs when the Moon passes through Earth's ____.

A. atmosphere
B. orbit
C. shadow
D. umbra

Master ID:	3880219 Revision:	1
Correct:	C	
Standards:		
9-12.ESS1.B.1		

Directions: Answer the following question(s).

19 A student is asked to develop a model to illustrate the life cycle of our sun. Which factors must be included in the model?

A. Mass
B. Temperature
C. Stage
D. Composition
E. Location of the sun in the universe.
F. Distance between the sun and other stars.

Master ID:	3876544 Revision:	2
Correct:	ABCD	
Standards:	9-12.ESS1.A.1	

20 Small, icy bodies that have highly eccentric orbits and can be found in the Oort cloud or the Kuiper belt are called _____.

A. meteors
B. comets
C. asteroids
D. meteorites

Master ID:	3894498 Revision:	1
Correct:	B	
Standards:	9-12.ESS1.B.1	

21 Most asteroids lie between which **two** planets?

A. Earth
B. Mars
C. Jupiter
D. Saturn
E. Uranus

Master ID:	3894494 Revision:	1
Correct:	BC	
Standards:	9-12.ESS1.B.1	

22 Which planet has a ring system around it?

A. Mercury
B. Venus
C. Earth
D. Saturn
E. Mars

Master ID:	3894487 Revision:	1
Correct:	D	
Standards:	9-12.ESS1.B.1	

23 Jupiter is a very unique planet with some distigushing features. Select the features that describe Jupiter. Select all that apply.

A. Largest Planet in the Solar System
B. No moons
C. Giant blue spot
D. 63+ moons
E. Liquid water present on the surface
F. No atmosphere

Master ID:	3894481 Revision:	1
Correct:	AD	
Standards:	9-12.ESS1.B.1	

24 A year on Jupiter is 4,333 days long. A year on Mercury is 88 days long. Why do planets have different length years?

A. A year is longer on larger planets.
B. Each planet has its own orbital period.
C. Some planets are larger than other planets.
D. Planets exert a gravitational force on other planets.

Master ID:	3894580 Revision:	1
Correct:	B	
Standards:	9-12.ESS1.B.1	

Directions: Answer the following question(s).

25 The four inner planets are rocky and small. Which description best fits the next four outer planets?

A. They are also rocky and small
B. They are small and made of ice
C. They are large and made of ice
D. They are very large and made of gases

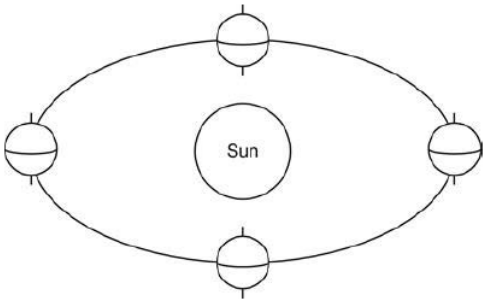
Master ID:	3894594 Revision:	1
Correct:	D	
Standards:		
9-12.ESS1.B.1		

26 When the solar system formed, smaller bodies joined together through collision and the force of gravity to form larger bodies called

A. Moons
B. Asteroids
C. Protoplanets
D. Planetesimals

Master ID:	3894603 Revision:	1
Correct:	D	
Standards:		
9-12.ESS1.B.1		

27 Mr. Jones made a model to show how the position of Earth around the Sun can affect seasons.



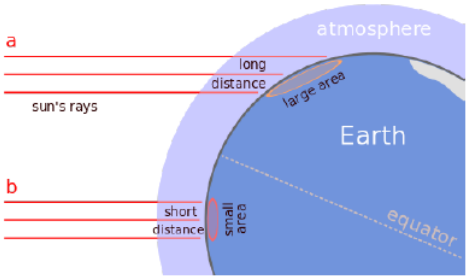
What improvement should Mr. Jones make to his diagram to correctly show how Earth's position affects the seasons?

A. add the tilt of the Earth
B. show the rotation of the Earth
C. show the moon orbiting the Sun
D. add the other planets that orbit the sun

Master ID:	3894634 Revision:	1
Correct:	A	
Standards:		
9-12.ESS1.B.1		

Directions: Answer the following question(s).

28 Make the best conclusions about what season you would expect it to be in the picture below. Select all that apply.



A. It is summertime in the northern hemisphere
B. It is summertime in the southern hemisphere
C. It is wintertime in the northern hemisphere
D. It is wintertime in the southern hemisphere

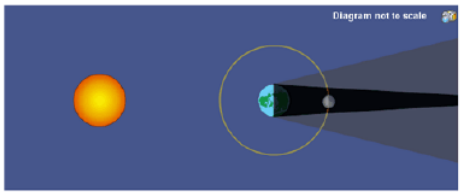
Master ID:	3894614 Revision:	1
Correct:	BC	
Standards:		
9-12.ESS1.B.1		

29 Two times during the year, the Sun is directly over the equator. What are these times called?

A. equinoxes
B. solstices
C. eclipses
D. capricorn and cancer

Master ID:	3894658 Revision:	1
Correct:	A	
Standards:		
9-12.ESS1.B.1		

30



What is this diagram showing?

A. an equinox
B. a lunar eclipse
C. a solar eclipse
D. the winter solistice

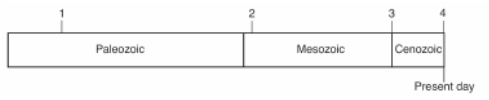
Master ID:	3894648 Revision:	1
Correct:	B	
Standards:		
9-12.ESS1.B.1		

APPENDIX C

UNIT 2 EARTH'S HISTORY TEST

Directions: Answer the following question(s).

1 The geologic time line below represents the three most recent geologic eras. The numbers represent events in Earth's history.

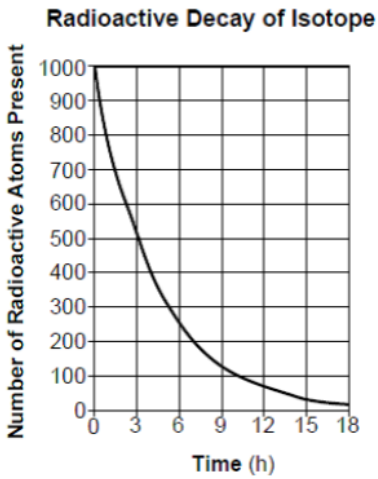


Which number best represents when humans are inferred to have first appeared on Earth?

A. 1
B. 2
C. 3
D. 4

Master ID:	3897452 Revision:	1
Correct:	D	
Standards:		
9-12.ESS2.E.1		

2



Based on the graph, what is the approximate number of radioactive atoms of Isotope X that are present when 8 hours of decay have occurred?

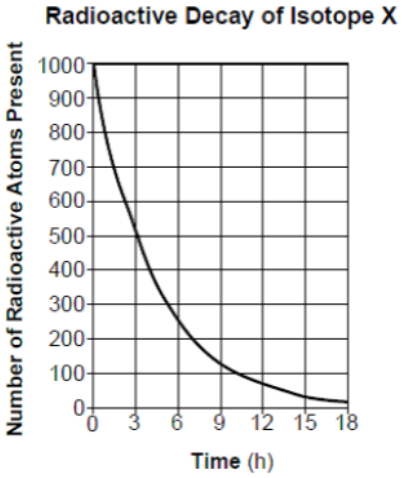
A. 50
B. 100
C. 155
D. 200

Master ID:	3897461 Revision:	2
Correct:	C	
Standards:		
9-12.ESS1.C.2		

Continue: Turn to the next page.

Directions: Answer the following question(s).

3

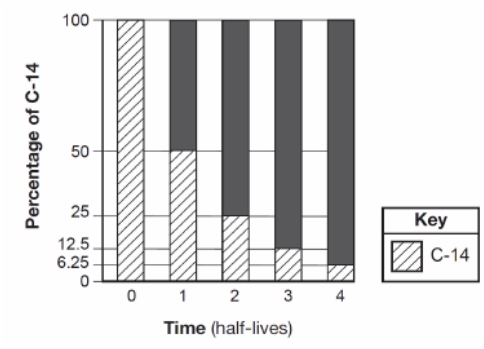


Based on the graph, the half-life of this radioactive isotope is

A. 6 hours
B. 9 hours
C. 3 hours
D. 12 hours

Master ID:	3897462 Revision:	1
Correct:	C	
Standards:		
9-12.ESS1.C.2		

4 A bar graph of the radioactive decay of carbon-14 is shown below.



The solid black sections of the bars on the graph represent the percentages of

A. carbon-14 from the original sample that has not decayed
B. uranium-238 from the original sample that has not decayed
C. lead-206 decay product resulting from the radioactive decay
D. carbon-14 decay product resulting from the radioactive decay

Master ID:	3897464 Revision:	2
Correct:	D	
Standards:		
9-12.ESS1.C.2		

Continue: Turn to the next page.

Directions: Answer the following question(s).

5 The table below shows the radioactive decay of carbon-14. Part of the table has been left blank.

Half-Life	Original Carbon-14 Remaining (%)	Number of Years
0	100	0
1	50	5,700
2	25	11,400
3		17,100
4		
5		

After 22,800 years, approximately what percentage of the original carbon-14 remains?

A. 15%
B. 6.25%
C. 12.5%
D. 3.125%

Master ID: 3897469 Revision: 1
Correct: B
Standards:
9-12.ESS1.C.2

6 The table below shows the radioactive decay of carbon-14. Part of the table has been left blank.

Half-Life	Original Carbon-14 Remaining (%)	Number of Years
0	100	0
1	50	5,700
2	25	11,400
3		17,100
4		
5		

A fossil formed 11,400 years ago. Which percentage of the original amount of carbon-14 remains in the fossil?

A. 100%
B. 50%
C. 25%
D. 12.5%

Master ID: 3897475 Revision: 1
Correct: C
Standards:
9-12.ESS1.C.2

7 The major source of oxygen in Earth's early Proterozoic atmosphere is inferred to have been produced by

A. oceanic cyanobacteria
B. outgassing from volcanic eruptions
C. radioactive decay in Earth's inner core
D. evaporation of ocean water

Master ID: 3897477 Revision: 1
Correct: A
Standards:
9-12.ESS2.E.1

Directions: Answer the following question(s).

8 Which sequence of geologic events is in the correct order, from oldest to most recent?

A. oxygen begins to enter the atmosphere --> earliest stromatolites --> initial opening of the Atlantic Ocean --> extinction of the dinosaurs

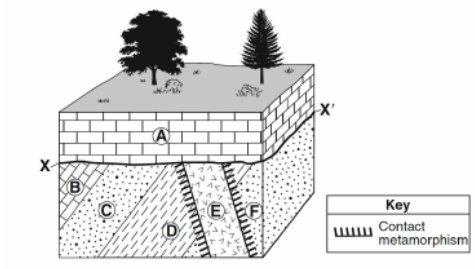
B. extinction of the dinosaurs --> initial opening of the Atlantic Ocean --> oxygen begins to enter the atmosphere --> earliest stromatolites

C. initial opening of the Atlantic Ocean --> earliest stromatolites --> oxygen begins to enter the atmosphere --> extinction of the dinosaurs

D. earliest stromatolites --> oxygen begins to enter the atmosphere --> initial opening of the Atlantic Ocean --> extinction of the dinosaurs

Master ID:	3897483 Revision:	1
Correct:	D	
Standards:		
9-12.ESS2.E.1		

9



Which sequence best describes the geologic history, from oldest to youngest, that occurred at this site?

A. deposition of F, D, C, B --> intrusion of E --> uplift and erosion --> deposition of A

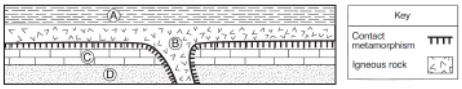
B. intrusion of E --> deposition of F, D, C, B --> uplift and erosion --> deposition of A

C. deposition of F, D, C, B, A --> uplift and erosion --> intrusion of E

D. deposition of F, D, C, B, A --> intrusion of E --> uplift and erosion

Master ID:	3897499 Revision:	1
Correct:	A	
Standards:		
9-12.ESS1.C.1		

10 The cross section below shows four rock units, A, B, C, D.



Which rock unit is the youngest?

A. A

B. B

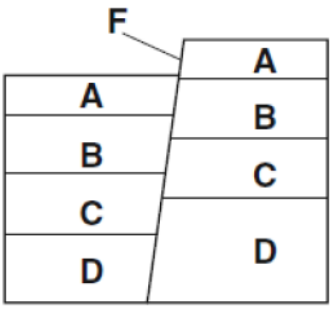
C. C

D. D

Master ID:	3897512 Revision:	1
Correct:	A	
Standards:		
9-12.ESS1.C.1		

Directions: Answer the following question(s).

11 The cross section below shows rock layers A, B, C, D, and fault F. The rock layers have not been overturned.



Which sequence places the rock layers and fault in order from oldest to youngest?

A. D --> C --> B --> A --> F
B. A --> B --> C --> D --> F
C. F --> D --> C --> B --> A
D. F --> A --> B --> C --> D

Master ID:	3897521 Revision:	1
Correct:	A	
Standards:	9-12.ESS1.C.1	

12 Index fossils are useful to geologists if the fossils are _____. **Select all that apply.**

A. found in a narrow geologic time period
B. found over a broad geologic time period
C. are uncommon
D. not easily recognized
E. widely distributed across Earth

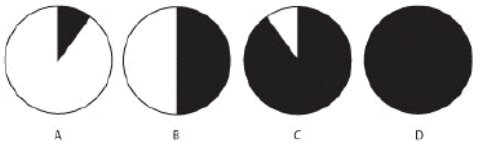
Master ID:	3897533 Revision:	1
Correct:	AE	
Standards:	9-12.ESS2.E.1	

13 Which of the following is marked by the appearance of organisms with hard body structures (shells, bone, etc.)?

A. the beginning of the Cenozoic
B. the end of the Mesozoic
C. the beginning of the Cretaceous
D. the end of the Precambrian

Master ID:	3898234 Revision:	2
Correct:	D	
Standards:	9-12.ESS2.E.1	

14 The shaded area of which graph represents the percentage of geologic time that is part of the Precambrian?

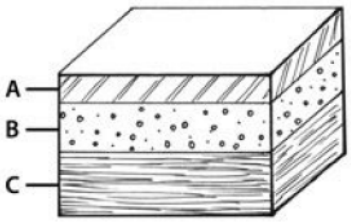


A. A
B. B
C. C
D. D

Master ID:	3898242 Revision:	1
Correct:	C	
Standards:	9-12.ESS1.C.2	

Directions: Answer the following question(s).

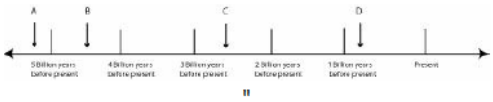
15 The principle of superposition can be used to determine what fact about the layers of rock below?



A. the actual age of these rock layers
B. the relative densities of these rock layers
C. the actual temperatures of these rock layers
D. the relative age of these rock layers

Master ID:	3898250 Revision:	1
Correct:	D	
Standards:		
	9-12.ESS1.C.2	

16 Which point on this time line should be labeled "Formation of the Earth?



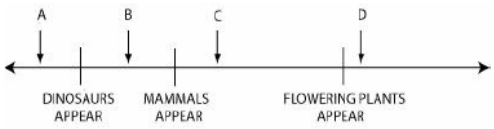
A. A
B. B
C. C
D. D

Master ID:	3898258 Revision:	1
Correct:	B	
Standards:		
	9-12.ESS1.C.2	

17 Molds, casts, coprolites, and petrified wood are all examples of _____.

A. Fossils
B. Radioactive isotopes
C. Tertiary Epochs
D. Cenozoic Eras

Master ID:	3898263 Revision:	1
Correct:	A	
Standards:		
	9-12.ESS2.E.1	

18 

Which point on the timeline best indicates the time when birds first appear?

A. A
B. B
C. C
D. D

Master ID:	3898271 Revision:	1
Correct:	C	
Standards:		
	9-12.ESS2.E.1	

Directions: Answer the following question(s).

19 Why are there more fossils of ammonites (a shelled squid) than there are of jellyfish?

A. Ammonites have lived in the oceans for a longer period of time.

B. Jellyfish don't die and sink to the bottom of the ocean.

C. Jellyfish have only lived in areas where fossilization doesn't occur.

D. Ammonites have a hard shell and jellyfish have no hard parts.

Master ID: 3898288 Revision: 2
Correct: D
Standards:
9-12.ESS2.E.1

20 The end of which era is marked by the largest extinction event in Earth's history?

A. Cenozoic

B. Mesozoic

C. Paleozoic

D. Precambrian

Master ID: 3898310 Revision: 1
Correct: C
Standards:
9-12.ESS2.E.1

21 Environmental effects of the impact of a meteorite 66.4 million years ago may have led to the extinction of many species on Earth. Which evidence best supports this theory?

A. The Cenozoic Era began 66.4 million years ago when the Mesozoic Era ended.

B. Iridium found in meteorites is also present in rock layers that are 66.4 million years old.

C. Many other meteorite impact sites have been identified on Earth

D. Many asteroids are found between Mars and Jupiter

Master ID: 3898324 Revision: 1
Correct: B
Standards:
9-12.ESS1.C.2

22 Identical rock types, identical fossils, and very similar mountain ranges are found on different continents that are separated by a wide ocean. Which of these best explains these observations?

A. Organisms traveled between these continents on land bridges.

B. The same forces erode mountains in different locations.

C. These continents were joined together at one time in the past.

D. Some rock types are very common and are found everywhere.

Master ID: 3898349 Revision: 1
Correct: C
Standards:
9-12.ESS1.C.1

Directions: Answer the following question(s).

23

Table of Geologic Time

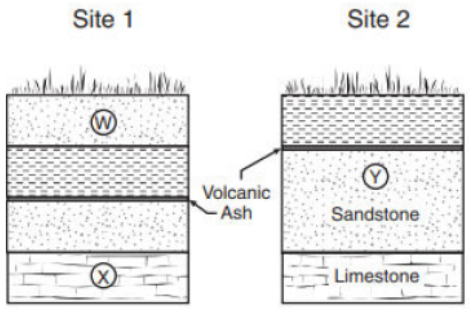
Era	Period	Years Before the Present
Cenozoic	Quaternary	recent – 2 million
	Tertiary	2 – 65 million
Mesozoic	Cretaceous	65 – 136 million
	Jurassic	136 – 190 million
	Triassic	190 – 225 million
Paleozoic	Permian	225 – 280 million
	Carboniferous	280 – 345 million
	Devonian	345 – 395 million
	Silurian	395 – 430 million
	Ordovician	430 – 500 million
	Cambrian	500 – 570 million
Precambrian		570 million – 4.6 billion

Rocks found on land are up to 3.8 billion years old, but those in the ocean are no more than 180 million years old. Using the information shown, during which era could parts of the ocean floor have formed?

A. Jurassic
B. Paleozoic
C. Precambrian
D. Mesozoic

Master ID: 3898369 Revision: 1
Correct: D
Standards:
9-12.ESS1.C.1

24



These geologic cross sections show the location of three fossilized species (W, X, and Y) found in rock layers at two nearby sites. Species X is probably the oldest species because it is found _____.

A. below species W
B. in the lowest layer
C. above the ash layer
D. in sandstone

Master ID: 3898386 Revision: 1
Correct: B
Standards:
9-12.ESS2.E.1

25 Which groups of organisms went extinct between the Cretaceous Tertiary Periods? **Select all that apply.**

A. Birds
B. Mammals
C. Flying reptiles
D. Dinosaurs
E. Fish
F. Sharks

Master ID: 3898472 Revision: 2
Correct: CD
Standards:
9-12.ESS1.C.2

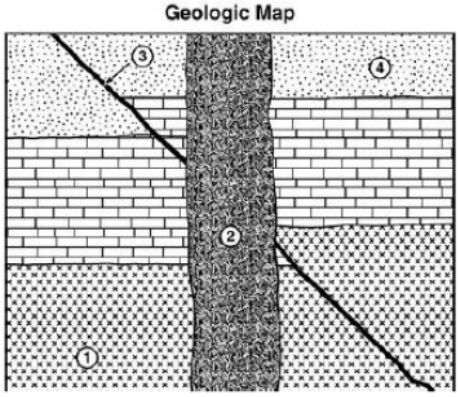
Directions: Answer the following question(s).

26 Precambrian time consists of which of the following. **Select all that apply.**

A. Hadean Eon
B. Phanerozoic Eon
C. Archean Eon
D. Cambrian Period
E. Proterozoic Eon

Master ID:	3898448 Revision:	1
Correct:	ACE	
Standards:	9-12.ESS1.C.2	

27



What principal would be used to determine the relative ages of fault 3 and intrusion 2?

A. Principle of original horizontality
B. Principle of superposition
C. Principle of inclusions
D. Principle of cross-cutting relationships

Master ID:	3899203 Revision:	1
Correct:	D	
Standards:	9-12.ESS1.C.1	

28 What life form dominated the terrestrial environment during the Mesozoic?

A. Amphibians
B. Birds
C. Mammals
D. Reptiles

Master ID:	3899200 Revision:	1
Correct:	D	
Standards:	9-12.ESS2.E.1	

29 Many of the large coal deposits were formed during which geologic time period?

A. Cambrian
B. Devonian
C. Carboniferous
D. Permian

Master ID:	3899198 Revision:	1
Correct:	C	
Standards:	9-12.ESS2.E.1	

30 Select the periods that make up the Mesozoic Era. **Select all that apply.**

A. Cambrian
B. Permian
C. Triassic
D. Phanerozoic
E. Jurassic
F. Cretaceous
G. Cenozoic

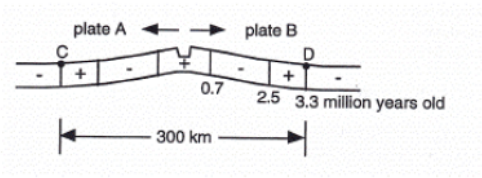
Master ID:	3898465 Revision:	2
Correct:	CEF	
Standards:	9-12.ESS2.E.1	

APPENDIX D

UNIT 3 PLATE TECTONICS TEST

Directions: Answer the following question(s).

1



How many reversals of Earth's magnetic field are depicted in the diagram above?

A. 3
B. 4
C. 6
D. 7

Master ID:	3950053 Revision:	1
Correct:	B	
Standards:	9-12.ESS2.A.1	

2 Which of the following landforms results from divergence of continental crust?

A. A mountain range
B. A deep sea trench
C. A rift valley
D. Volcanic island arc

Master ID:	3950046 Revision:	1
Correct:	C	
Standards:	9-12.ESS2.A.1	

3 Which types of plate boundaries produce volcanoes? **Select all that apply.**

A. Transform boundaries
B. Divergent boundaries
C. Continental-continental convergent boundaries
D. Continental-oceanic convergent boundaries
E. Oceanic-oceanic convergent boundaries

Master ID:	3950032 Revision:	2
Correct:	BDE	
Standards:	9-12.ESS2.A.1	

4 One kind of evidence that supports Wegener's hypothesis is that _____.

A. the same magnetic directions exist on different continents
B. major rivers on different continents match
C. land bridges still exist that connect major continents
D. fossils of the same organism have been found on different continents

Master ID:	3950021 Revision:	1
Correct:	D	
Standards:	9-12.ESS2.A.1	

5 When an earthquake occurs, energy radiates in all directions from its source, which is called the _____.

A. epicenter
B. focus
C. fault
D. seismic center

Master ID:	3950015 Revision:	1
Correct:	B	
Standards:	9-12.ESS2.A.1	

6 A fault is _____.

A. a place on Earth where earthquakes cannot occur
B. a fracture in the Earth where movement has occurred
C. the place on Earth's surface where structures move during an earthquake
D. another name for an earthquake

Master ID:	3950003 Revision:	1
Correct:	B	
Standards:	9-12.ESS1.C.1	

Directions: Answer the following question(s).

7 When Alfred Wegener proposed that the continents had changed position over time, many scientists rejected his proposal even though some of the evidence he presented was compelling. Which of the following describes the primary scientific reason many geologists originally rejected Wegener's continental drift proposal?

A. He was trained in a different scientific discipline and was considered an amateur.
B. His hypothesis lacked a convincing mechanism to explain what forces moved the continents.
C. He did not defend and argue the merits of his ideas since evidence was strong.
D. His field work was poorly executed and lacked the rigor associated with most sciences of the day.

Master ID:	3946705 Revision:	1
Correct:	B	
Standards:	9-12.ESS1.C.1 9-12.ESS2.A.1	

8 A magma's viscosity is directly related to its _____.

A. depth
B. age
C. color
D. silica content

Master ID:	3950107 Revision:	1
Correct:	D	
Standards:	9-12.ESS2.A.1 9-12.ESS2.A.2	

9 According to whole-mantle convection, _____.

A. small amounts of material from the lower mantle move upward to the surface
B. large chunks of continental crust are pulled down into the lower mantle
C. material from the inner core rises into the mantle to form super hot plumes
D. slabs of cold oceanic lithosphere move down into the lower mantle

Master ID:	3950103 Revision:	1
Correct:	D	
Standards:	9-12.ESS2.A.3	

10 Thermal convection that drives plate motion is caused by _____.

A. seafloor spreading
B. an unequal distribution of heat
C. gravity
D. subduction

Master ID:	3950102 Revision:	1
Correct:	B	
Standards:	9-12.ESS2.A.3	

11 The main source of downward convection flow in the mantle is called _____.

A. ridge-pull
B. ridge-push
C. slab-push
D. slab-pull

Master ID:	3950099 Revision:	1
Correct:	D	
Standards:	9-12.ESS2.A.3	

Continue: Turn to the next page.

Directions: Answer the following question(s).

12 Strips of alternating magnetic polarities found in rock in the ocean basins _____.

A. conflict with the theory of plate tectonics
B. provide evidence that Earth's magnetic field has never reversed polarity
C. indicate changes in Earth's gravitational field
D. provide evidence for seafloor spreading

Master ID:	3950094 Revision:	1
Correct:	D	
Standards:		
	9-12.ESS1.C.1	

13 Why are subduction zones not commonly found at convergent continental-continental boundaries?

A. Continental lithosphere is too dense to be force down into the mantle.
B. Oceanic lithosphere is too buoyant to be force down into the mantle.
C. Continental lithosphere is too buoyant to be forced down into the mantle.
D. Subduction ones are never found at convergent boundaries.

Master ID:	3950089 Revision:	1
Correct:	C	
Standards:		
	9-12.ESS2.A.3	

14 What type of boundary occurs where two plates move together, causing one plate to descend into the mantle beneath the other plate?

A. transform fault boundary
B. divergent boundary
C. transitional boundary
D. convergent boundary

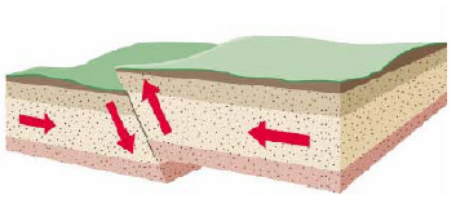
Master ID:	3950081 Revision:	1
Correct:	D	
Standards:		
	9-12.ESS2.A.1	
	9-12.ESS2.A.3	

15 In the plate tectonic theory, a plate can be made up of _____.

A. the crust and uppermost mantle
B. oceanic and continental crust only
C. the crust and entire mantle
D. the asthenosphere only

Master ID:	3950077 Revision:	1
Correct:	A	
Standards:		
	9-12.ESS2.A.1	

16



This kind of fault is caused by _____.

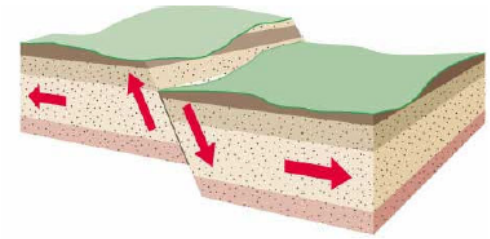
A. Tension
B. Compression
C. Shear

Master ID:	3950535 Revision:	1
Correct:	B	
Standards:		
	9-12.ESS2.A.1	

Continue: Turn to the next page.

Directions: Answer the following question(s).

17

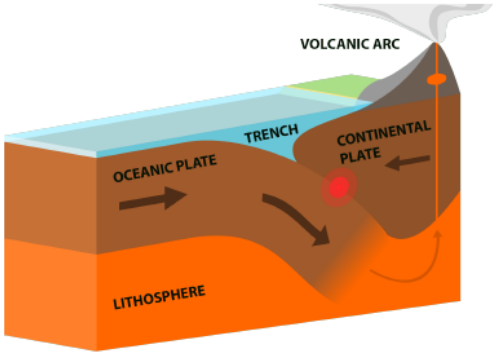


What type of fault is shown?

A. Normal fault
B. Reverse Fault
C. Shear
D. Strike-slip

Master ID:	3950520 Revision:	1
Correct:	A	
Standards:		
	9-12.ESS1.C.1	
	9-12.ESS2.A.2	

18



What type of plate boundary resulted in the volcanic activity illustrated above?

A. Divergent plate boundary
B. Oceanic-oceanic convergent boundary
C. Oceanic-continental convergent plate boundary
D. continental-continental plate boundary

Master ID:	3950508 Revision:	1
Correct:	C	
Standards:		
	9-12.ESS2.A.1	

19 Which of the following is responsible for the partial melting of rock beneath ocean ridges?

A. chemical reactions with atmospheric oxygen
B. increase in pressure
C. increase in temperature
D. decrease in pressure

Master ID:	3950493 Revision:	1
Correct:	D	
Standards:		
	9-12.ESS2.A.3	

20 What type of volcano is built almost entirely from ejected lava fragments?

A. Cinder cone
B. Composite cone
C. Shield volcano
D. Stratovolcano

Master ID:	3950481 Revision:	1
Correct:	A	
Standards:		
	9-12.ESS2.A.1	

21 Highly explosive volcanoes tend to have magma with which properties? **Select all that apply.**

A. Low silica content
B. High silica content
C. Low viscosity
D. High viscosity
E. High gas content
F. Low gas content

Master ID:	3950467 Revision:	1
Correct:	BDE	
Standards:		
	9-12.ESS2.A.2	
	9-12.ESS2.A.3	

Directions: Answer the following question(s).

22 The amount of damage done to structures by an earthquake is the earthquake's _____.

A. Intensity
B. Amplitude
C. Probability
D. Seismic gap

Master ID:	3950544 Revision:	1
Correct:	A	
Standards:	9-12.ESS1.C.1	

23 What happens to a rock that undergoes elastic deformation once the stress is removed?

A. It returns to its original shape
B. It undergoes plastic deformation
C. It breaks to generate an earthquake
D. It does not change shape

Master ID:	3950541 Revision:	2
Correct:	A	
Standards:	9-12.ESS2.A.1	

24 In what order do earthquake waves arrive at seismic stations?

A. P-Waves --> S-Waves --> Surface Waves
B. S-Waves --> P-Waves --> Surface Waves
C. S-Waves --> Surface Waves --> P-Waves
D. Surface Waves --> P-Waves --> S-Waves

Master ID:	3951083 Revision:	1
Correct:	A	
Standards:	9-12.ESS2.A.2	

25 What can form when two continental plates collide? **Select all that apply.**

A. Volcanoes
B. Earthquakes
C. Rift valleys
D. Oceans
E. Mountain ranges
F. Ocean trenches

Master ID:	3951080 Revision:	2
Correct:	BE	
Standards:	9-12.ESS1.C.1	

26 Convection occurs because heated material becomes

A. Less dense and rises
B. More dense and rises.
C. More dense and sinks.
D. Less dense and sinks

Master ID:	3951075 Revision:	1
Correct:	A	
Standards:	9-12.ESS2.A.3	

Directions: Answer the following question(s).

27 Based upon the data below, what conclusions can be drawn as to the region of the United States that has the most active fault lines that cause earthquakes?

Earthquakes in the United States Greater Than 3.5 on the Richter Scale

State	Number of Earthquakes > 3.5	Percent of Total Earthquakes (%)
Alaska	12,053	57.2
California	4,895	23.2
Hawaii	1,533	7.3
Nevada	778	3.7
Utah	139	0.7
Arkansas	34	0.2
Tennessee	22	0.1
Indiana	6	-
Connecticut	0	-
Florida	0	-

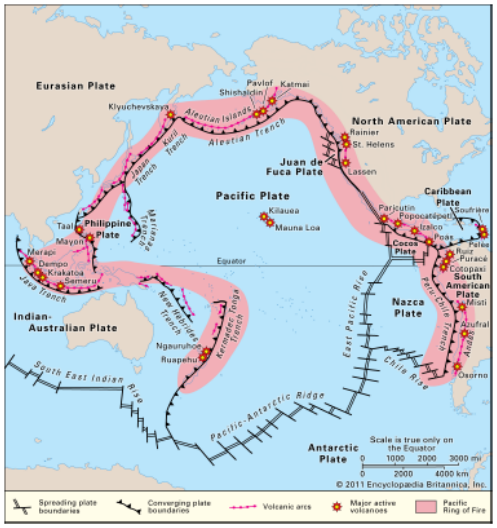
A. The east coast has the most active fault lines, because it had the fewest number of earthquakes.

B. The midwest has the greatest number of active fault lines because it had more earthquakes than the east and west coast.

C. The west coast has more active fault lines than the rest of the country because it has the largest number of earthquakes.

D. All regions in the United States have equal numbers of active fault lines.

Master ID: 3951071 Revision: 1
Correct: C
Standards:
9-12.ESS2.A.1

28 

The area along the rim of the Pacific Ocean has so many volcanoes it is often referred to as the "Ring of Fire." Why are there so many volcanoes in this area than in the center of the North American Plate?

A. The transformational plate boundaries that surround North America keep volcanoes from forming there.

B. The air temperature is warmer in the center of the Pacific Ocean than the air over North America, so more volcanoes are able to form and erupt.

C. There are many more divergent plate along the edges of the Pacific Ocean rim area than there are around North America, so more volcanoes can form.

D. The Pacific Ocean has many convergent plate boundaries, which releases more energy than the stable continental plate under North America.

Master ID: 3951055 Revision: 1
Correct: D
Standards:
9-12.ESS1.C.1

Directions: Answer the following question(s).

29 Which of the following are associated with divergent plate boundaries?

A. SIlica rich lavas
B. Basaltic lavas
C. Deep earthquakes
D. Shallow earthquakes
E. Tension (stretching) stresses
F. Compression stresses

Master ID: 3951096 Revision: 2
Correct: BDE
Standards:
9-12.ESS1.C.1

30 One remarkable realization associated with the discovery of seafloor spreading was that _____.

A. the rotational poles of the Earth have migrated.
B. mountains are more dense than the mantle.
C. the crust of the continents is more dense than the crust of the ocean.
D. the crust of the oceans is very young relative to the age of the crust of the continents.

Master ID: 3951103 Revision: 1
Correct: D
Standards:
9-12.ESS1.C.1

APPENDIX E

UNIT 4 GEOLOGY TEST

Directions: Answer the following question(s).

1 Which characteristic of a mineral is determined by rubbing the mineral across an unglazed porcelain plate and sometimes leaves a colored powdered streak on the plate's surface?

A. Fracture
B. Color
C. Hardness
D. Streak

Master ID:	3973356 Revision:	1
Correct:	D	
Standards:		
9-12.ESS3.A.1		

2 Which **three (3)** of the following are required to be classified as a mineral?

A. Be created by a living organism
B. Be inorganic
C. Have randomly arranged atoms
D. Have a specific chemical composition
E. have a crystalline structure
F. Have multiple chemical formulas

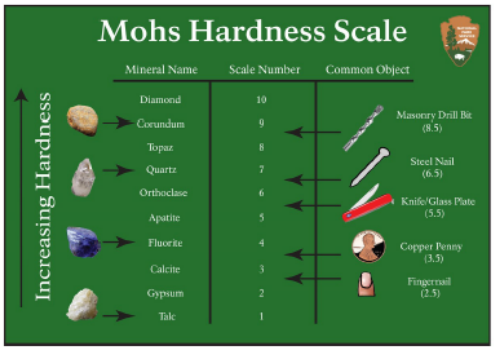
Master ID:	3973317 Revision:	1
Correct:	BDE	
Standards:		
9-12.ESS3.A.1		

3 The color of a mineral, such as fluorite, changes due to _____.

A. small amounts of different elements
B. differences in hardness
C. differences in the crystal structure
D. differences in the density

Master ID:	3973307 Revision:	1
Correct:	A	
Standards:		
9-12.ESS3.A.1		

4



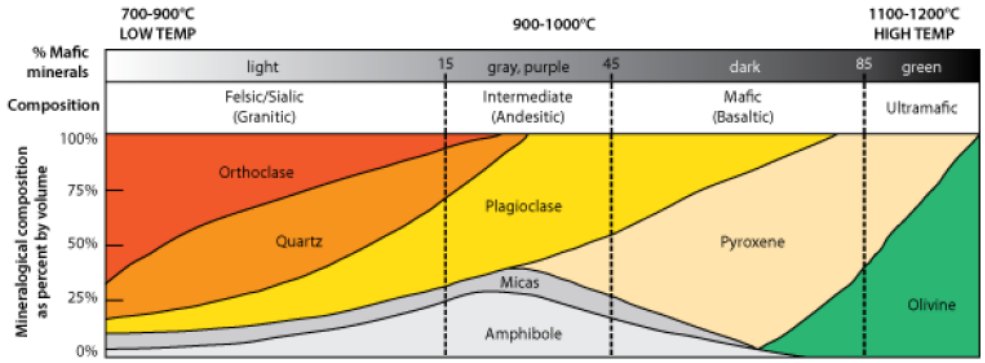
What is the hardness of an unknown mineral that scratches glass, but will not scratch quartz?

A. 5.0
B. 7.5
C. 6.0
D. 8.0

Master ID:	3967867 Revision:	2
Correct:	C	
Standards:		
9-12.ESS3.A.2		

Directions: Read the passage below and answer the question(s) that follow.

Igneous Rock Identification



Texture	Rock names			
Coarse-grained	Granite	Diorite	Gabbro	Peridotite
Fine-grained	Rhyolite	Andesite	Basalt	Uncommon (rarely encountered)
Pyroclastic	Rhyolite Tuff	Andesite Tuff	Basalt Tuff	
Glassy	Obsidian			
Vesicular	Pumice (like meringue)		Scoria	

5 Which of the following igneous rocks are considered extrusive igneous rocks? **Select all that apply.**

A. Rhyolite
B. Granite
C. Andesite
D. Basalt
E. Diorite
F. Peridotite
G. Gabbro

Master ID: 3973415 Revision: 2
Correct: ACD
Standards:
9-12.ESS3.A.2

6 What minerals are most common in a sample of granite? **Select all that apply.**

A. Quartz
B. Orthoclase
C. Pyroxene
D. Olivine
E. Gold

Master ID: 3973411 Revision: 2
Correct: AB
Standards:
9-12.ESS3.A.2

Directions: Answer the following question(s) relating to the passage titled "Igneous Rock Identification".

7 Steve Rogers found an igneous rock while walking around his house. The rock was fine grained, dark in color, and had many holes in it. What kind of rock did Steve Rogers find.

A. Gabbro
B. Rhyolite
C. Granite
D. Basalt

Master ID:	3973403 Revision:	2
Correct:	D	
Standards:		
9-12.ESS3.A.1		

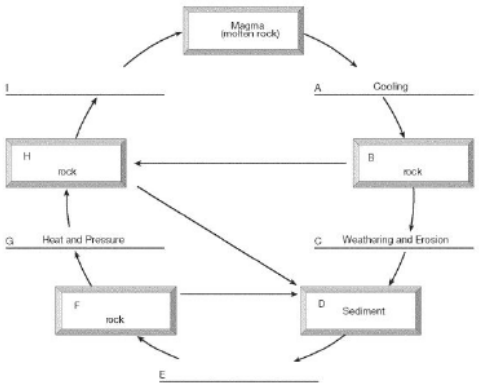
8 Which intrusive igneous rock could be composed of approximately 60% pyroxene, 25% plagioclase feldspar, 10% olivine, and 5% amphibole?

A. Granite
B. Rhyolite
C. Basalt
D. Gabbro

Master ID:	3977284 Revision:	1
Correct:	D	
Standards:		
9-12.ESS3.A.2		

Directions: Answer the following question(s).

9



In the figure above what type of rock should occur in the part of the rock cycle labeled B?

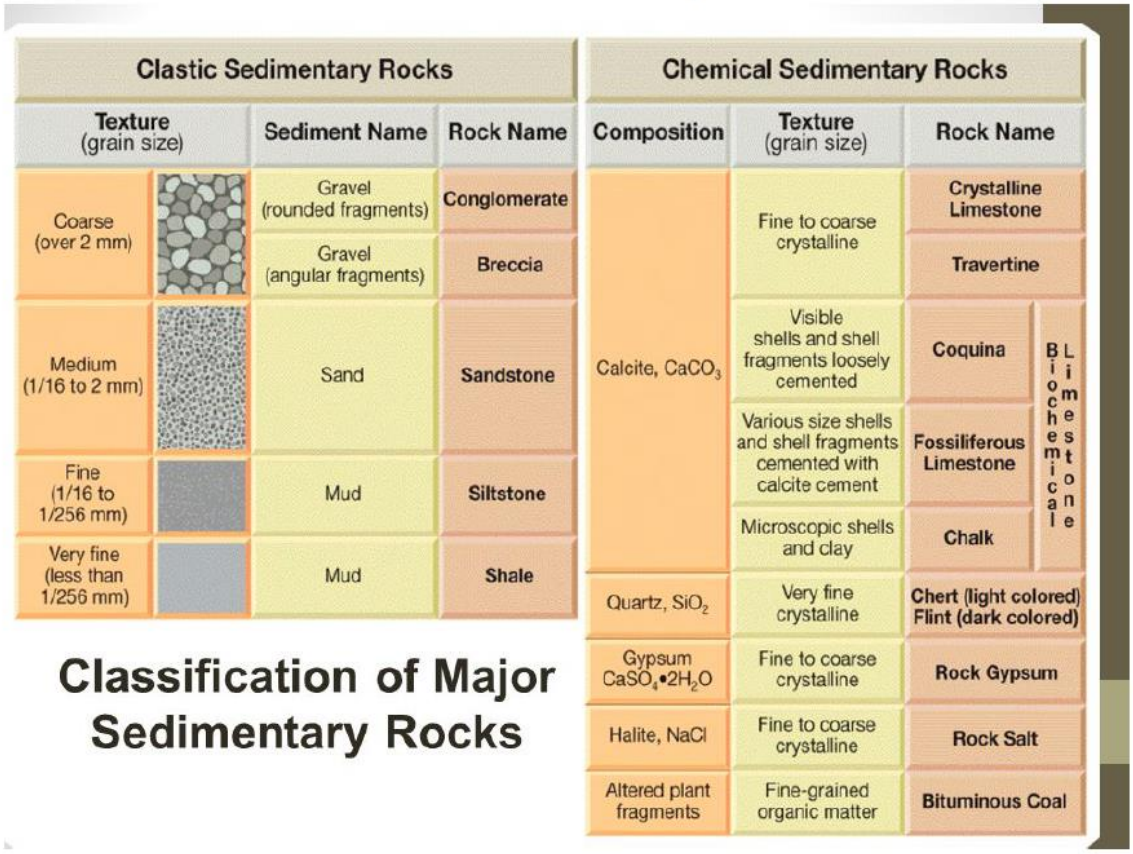
A. Lava
B. Igneous
C. Sedimentary
D. Metamorphic

Master ID:	3973387 Revision:	1
Correct:	B	
Standards:		
9-12.ESS3.A.2		

Continue: Turn to the next page.

Directions: Read the passage below and answer the question(s) that follow.

Classification of Sedimentary Rocks



Continue: Turn to the next page.

Directions: Answer the following question(s) relating to the passage titled "Classification of Sedimentary Rocks".

10 Which of the following rocks were formed by the evaporation of water or precipitation of minerals? **Select all that apply.**

A. Sandstone
B. Bituminous Coal
C. Rock Salt
D. Siltstone
E. Rock Gypsum
F. Conglomerate

Master ID: 3973444 Revision: 3
Correct: CE
Standards:
9-12.ESS3.A.1

11 Name a course-grained sedimentary rock that is composed of rounded fragments.

A. Conglomerate
B. Breccia
C. Sandstone
D. Rock Gypsum

Master ID: 3973434 Revision: 1
Correct: A
Standards:
9-12.ESS3.A.2

12 Which of the following sedimentary rocks are classified as clastic? **Select all that apply.**

A. Sandstone
B. Limestone
C. Chalk
D. Siltstone
E. Conglomerate
F. Travertine

Master ID: 3977352 Revision: 2
Correct: ADE
Standards:
9-12.ESS3.A.2

Directions: Answer the following question(s).

13 Fossils and ripple marks are found in _____.

A. Intrusive igneous rocks
B. non foliated metamorphic rocks
C. sedimentary rocks
D. foliated metamorphic rocks
E. extrusive igneous rocks

Master ID:	3973426 Revision:	1
Correct:	C	
Standards:		
9-12.ESS3.A.2		

14 Which of the following represents the correct order of the processes involved in sedimentary rock formation?

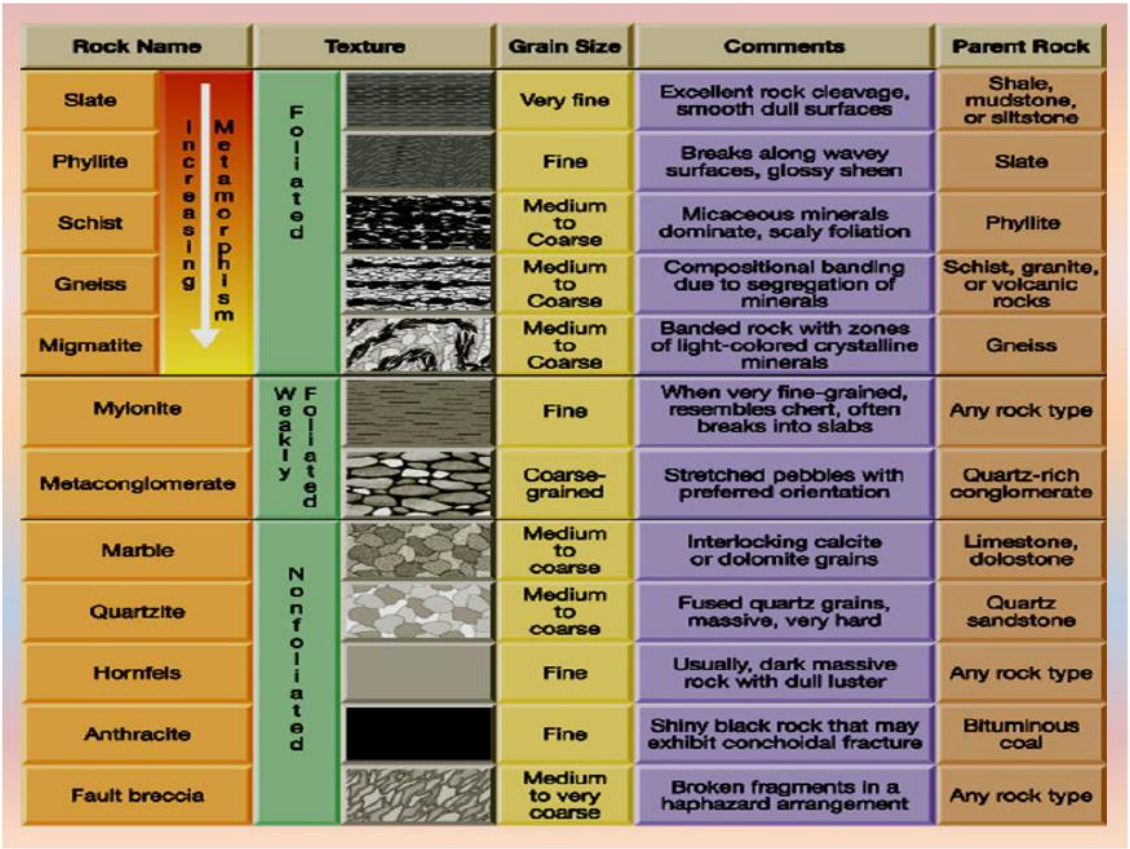
A. erosion, weathering, compaction, cementation, deposition
B. compaction, cementation, deposition, weathering, erosion
C. deposition, cementation, compaction, erosion, weathering
D. weathering, erosion, deposition, compaction, cementation

Master ID:	3973419 Revision:	1
Correct:	D	
Standards:		
9-12.ESS3.A.1		

Continue: Turn to the next page.

Directions: Read the passage below and answer the question(s) that follow.

Metamorphic Rock Classification



15 Which of the following metamorphic rocks exhibit foliated texture? **Select all that apply.**

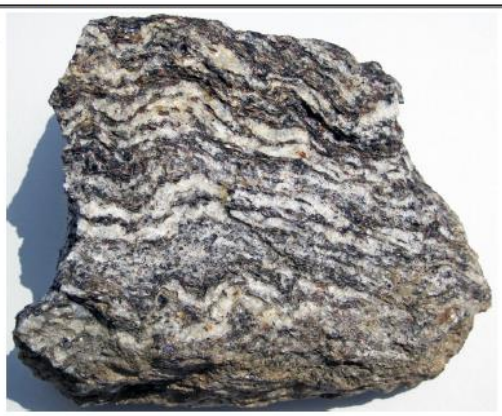
A. Marble
B. Slate
C. Quartzite
D. Anthracite
E. Gneiss

Master ID: 3977328 Revision: 3
Correct: BE
Standards:
9-12.ESS3.A.2

Continue: Turn to the next page.

Directions: Answer the following question(s) relating to the passage titled "Metamorphic Rock Classification".

16



Name the metamorphic rock pictured above?

A. Slate
B. Phyllite
C. Schist
D. Gneiss
E. Quartzite

Master ID:	3977772 Revision:	1
Correct:	D	
Standards:		
9-12.ESS3.A.1		

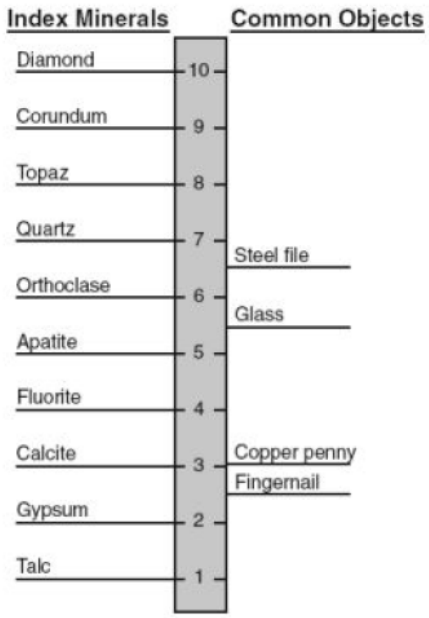
Directions: Answer the following question(s).

17 Metamorphic rock can be classified according to its _____. **Select all that apply.**

A. density
B. texture
C. color
D. composition

Master ID:	3977312 Revision:	1
Correct:	BD	
Standards:		
9-12.ESS3.A.2		

18 The diagram below shows the index minerals of Mohs hardness scale compared with the hardness of some common objects.



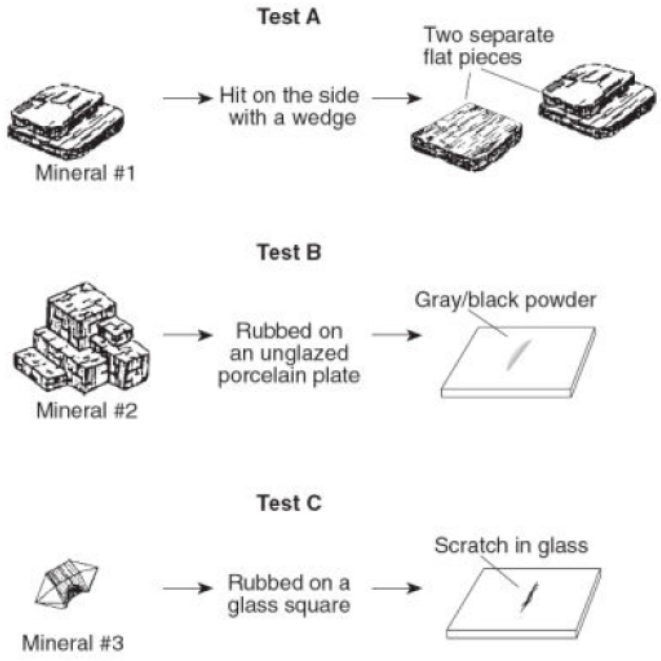
Which statement is best supported by the diagram?

A. A fingernail with scratch calcite but not gypsum.
B. Calcite will be scratched by a copper penny.
C. The mineral apatite will scratch quartz.
D. A steel file has a hardness of 7.5

Master ID:	4041893 Revision:	1
Correct:	B	
Standards:		
9-12.ESS3.A.2		

Directions: Read the passage below and answer the question(s) that follow.

Mineral Tests



19 The results of all three physical tests shown are most useful for determining the _____.

A. rate of weathering of the minerals.
B. identity of the minerals.
C. environment where the minerals formed.
D. geologic period when the minerals formed.

Master ID:	4041935 Revision:	1
Correct:	B	
Standards: 9-12.ESS3.A.1		

20 Which sequence correcly matches each test, A, B, and C, with the mineral property tested?

A. A - cleavage
B - streak
C - hardness
B. A - cleavage
B - hardness
C - streak
C. A - streak
B - cleavage
C - hardness
D. A - streak
B - hardness
C - cleavage

Directions: Answer the following question(s) relating to the passage titled "Mineral Tests".

Master ID:	4041929 Revision:	1
Correct:	A	
Standards:		
9-12.ESS3.A.1		

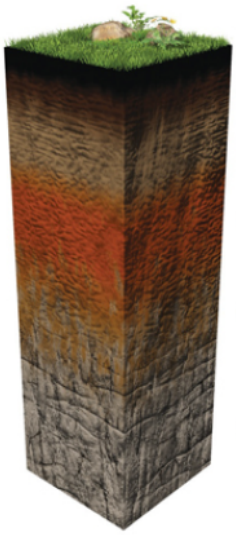
Directions: Answer the following question(s).

21 In which of the following climates would chemical weathering most readily occur?

A. wet and warm
B. dry and warm
C. wet and cool
D. dry and cool

Master ID:	4050725 Revision:	1
Correct:	A	
Standards:		
9-12.ESS2.C.1		

22

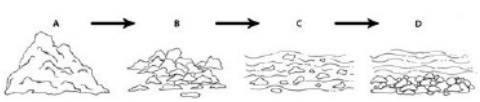


What does the O-horizon consist of?

A. clay
B. broken down bedrock
C. weathered rock and organic material
D. humus and leaf litter

Master ID:	4050692 Revision:	1
Correct:	D	
Standards:		
9-12.ESS3.C.1		

23



Which step in the diagram depicts erosion?

A. A
B. B
C. C
D. D

Master ID:	4050673 Revision:	2
Correct:	C	
Standards:		
9-12.ESS2.C.1		

24 Which is NOT an agent of chemical weathering?

A. water
B. temperature
C. oxygen
D. carbon dioxide

Master ID:	4050651 Revision:	1
Correct:	B	
Standards:		
9-12.ESS2.C.1		

25 Which of the following characteristics of water can be responsible for mechanical weathering?

A. Water flows down stream under gravity
B. Water combines with atmospheric gases to form acid rain
C. Water expands as it freezes.
D. Water reacts with and can dissolve many kinds of minerals.

Master ID:	4050737 Revision:	1
Correct:	C	
Standards:		
9-12.ESS2.C.1		

Directions: Answer the following question(s).

26 A rock is split or broken into smaller material without changing its composition. What type of weathering is occurring?

A. Oxidation
B. Surface area
C. Chemical weathering
D. Mechanical weathering

Master ID: 4053031 Revision: 1
Correct: D
Standards:
9-12.ESS2.C.1

27 Which of the following statements is true about wind transport?

A. Wind, like water, can only move materials downhill.
B. Wind and water have the same relative ability to erode materials.
C. Wind transport and erosion primarily occur in areas with little vegetative cover.
D. Generally, wind can carry particles as large as those transported by moving water.

Master ID: 4055762 Revision: 2
Correct: C
Standards:
9-12.ESS3.C.1

28 Solid fragments of material that come from the weathering of rocks are called _____.

A. soil
B. tectonic plates
C. minerals
D. sediment

Master ID: 4055777 Revision: 1
Correct: D
Standards:
9-12.ESS3.C.1

29 Which of the following happens when a river/ stream enters a large body of water?

A. The river slows down and deposits large amounts of sediment.
B. The river water increases its speed and carries out gully erosion.
C. The river water flows over the delta, causing exfoliation.
D. The river water erodes the shoreline and deposits barrier islands.

Master ID: 4056091 Revision: 1
Correct: A
Standards:
9-12.ESS2.C.1

30 Which describes a residual soil?

A. Soil from dediment deposited by glaciers.
B. Sand that has collected in a floodplain
C. Fine-grained sediment that was deposited by wind.
D. Layers of material that weathered from bedrock below.

Master ID: 4056080 Revision: 1
Correct: D
Standards:
9-12.ESS3.C.2

APPENDIX F

UNIT 5 METEOROLOGY TEST

Directions: Answer the following question(s).

1 Low-pressure systems are usually associated with _____ and _____ weather. **(select 2).**

A. cold
B. warm
C. sunny
D. cloudy
E. rainy
F. dry

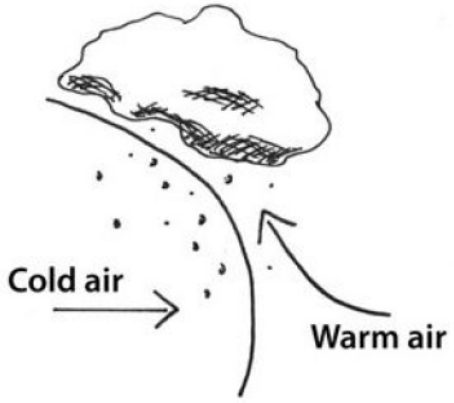
Master ID:	4067818 Revision:	1
Correct:	DE	
Standards:		
9-12.ESS3.D.2		

2 The Coriolis effect is due to the _____ of Earth.

A. revolution
B. rotation
C. shape
D. density

Master ID:	4067814 Revision:	1
Correct:	B	
Standards:		
9-12.ESS3.D.1		

3 A student draws the diagram below.



What type of front did the student make a diagram of?

A. stationary front
B. occluded front
C. cold front
D. warm front

Master ID:	4067811 Revision:	1
Correct:	C	
Standards:		
9-12.ESS2.D.1		

4 The hot and humid weather in Missouri during the summer is most likely due to what type of air mass?

A. Continental polar
B. Continental tropical
C. Maritime polar
D. Maritime tropical

Master ID:	4067800 Revision:	2
Correct:	D	
Standards:		
9-12.ESS3.D.1		

Directions: Answer the following question(s).

5 _____ can act as a lid or trap, thus worsening air-pollution problems.

A. Temperature inversions
B. Relative humidity
C. Lifted condensation levels
D. Convection currents

Master ID: 4067796 Revision: 1
Correct: A
Standards: 9-12.ESS3.D.2

6 Earth's atmosphere contains more _____ and _____ than any other substance. **(Select two).**

A. hydrogen
B. nitrogen
C. helium
D. oxygen
E. carbon dioxide
F. neon

Master ID: 4067795 Revision: 1
Correct: BD
Standards: 9-12.ESS3.D.1

7 Carbon dioxide levels in the atmosphere...

A. have been rising since the 1950s but leveled off in the early 2000s.
B. rose in the 1950s and 1960s, but are now stable.
C. have been declining since the 1970s.
D. have continued to rise since the 1950s.

Master ID: 4070983 Revision: 2
Correct: D
Standards: 9-12.ESS3.D.2

8 Outside one morning the plants are coated with water but it did not rain. What caused the plants to become wet?

A. a fog came in overnight
B. an inversion caused water to condense on the plants
C. the air near the plants cooled to below its dew point
D. this could not have happened; it must have rained

Master ID: 4070978 Revision: 1
Correct: C
Standards: 9-12.ESS2.D.1

9 What **two** features does an air mass have nearly identical throughout?

A. fog
B. humidity
C. air pressure
D. temperature
E. cloud cover

Master ID: 4070972 Revision: 1
Correct: BD
Standards: 9-12.ESS2.D.1

10 In which layer of the atmosphere does all weather take place?

A. Troposhere
B. Stratosphere
C. Mesosphere
D. Thermosphere

Master ID: 4070971 Revision: 1
Correct: A
Standards: 9-12.ESS2.D.1

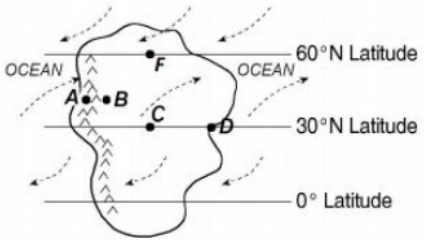
Directions: Answer the following question(s).

11 Which of the following decreases with an increase in altitude?

A. visibility
B. air temperature
C. air pressure

Master ID:	4070963 Revision:	1
Correct:	C	
Standards:		
9-12.ESS2.D.1		

12 The map below shows an imaginary continent on Earth. Arrows represent prevailing wind directions. Letters A through F represent locations on the continent. Locations A and B are at the same latitude and at the same elevation at the base of the mountains.



Over the course of a year, compared to location B, location A will have

A. less precipitation and warmer temperatures.
B. less precipitation and cooler temperatures.
C. more precipitation and cooler temperatures.
D. more precipitation and warmer temperatures.

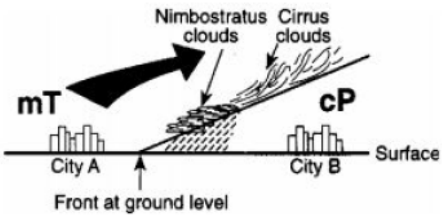
Master ID:	4071017 Revision:	2
Correct:	C	
Standards:		
9-12.ESS2.D.1		

13 Wind moves from regions of

A. high temperature toward regions if low temperature.
B. high humidity toward regions of low humidity.
C. high precipitation toward regions of low percipitation.
D. high pressure toward regions of low pressure.

Master ID:	4071000 Revision:	1
Correct:	D	
Standards:		
9-12.ESS2.D.1		

14



Why do clouds and precipitation usually occur along the frontal surface?

A. The warm air rises, expands, and cools.
B. The warm air sinks, explands, and warms.
C. The cool air rises, compresses and cools.
D. The cool air sinks, compresses, and warms.

Master ID:	4070993 Revision:	1
Correct:	A	
Standards:		
9-12.ESS2.D.1		

Directions: Answer the following question(s).

15 Which statement about carbon dioxide is true?

A. Burning fossil fuels increases atmospheric carbon dioxide levels.
B. Global temperatures depend on the total amount of carbon on Earth.
C. Human actions have little effect on the amount of carbon in circulation.
D. Oceans absorb carbon dioxide much faster than humans add it to the atmosphere.

Master ID:	4071046 Revision:	1
Correct:	A	
Standards:		
9-12.ESS2.D.1		
9-12.ESS3.D.2		

16 Certain gases in the atmosphere - water vapor, carbon dioxide, methane, and nitrous oxide - help maintain the Earth's temperatures and climate. These are called: _____.

A. ozone gases
B. solar gases
C. sun rise gases
D. greenhouse gases

Master ID:	4071037 Revision:	1
Correct:	D	
Standards:		
9-12.ESS2.D.1		

17 What is necessary for a hurricane to form? **Select all that apply.**

A. Cool air
B. An abundant supply of warm water.
C. An air of low pressure to allow lift to occur.
D. A high pressure system to allow the air to sink.
E. A polar air mass.

Master ID:	4073052 Revision:	1
Correct:	BC	
Standards:		
9-12.ESS3.D.1		

18 In many large cities the temperature during the day and night is often higher than in the surrounding areas. This is called the heat island effect, what causes this heat island effect in large cities?

A. Large amounts of trees planted in the city parks.
B. Large areas of low pressure building above the cities due to factories.
C. The tall buildings prevent clouds from forming above the cities.
D. The concrete and asphalt absorb more of the sun's rays heating the air around the cities.

Master ID:	4073043 Revision:	2
Correct:	D	
Standards:		
9-12.ESS3.D.1		
9-12.ESS3.D.2		

19 Which **two** of the following have contributed to global climate change?

A. the burning of fossil fuels
B. tree planting programs.
C. utilizing more renewable energy sources
D. deforestation

Master ID:	4073031 Revision:	1
Correct:	AD	
Standards:		
9-12.ESS3.D.2		

Directions: Answer the following question(s).

20 Over the past 200 years the Earth has continued to warm. If this trend continues what might be some effects? **Select all that apply.**

A. Glaciers will melt which will lead to sea level rise
B. Ice caps at the poles will grow leading to a decrease in sea levels.
C. Deserts will spread into fertile farmland regions
D. Farmland will spread into desert regions
E. Global temperatures will gradually rise.
F. Global temperatures will gradually decrease.

Master ID:	4073022 Revision:	1
Correct:	ACE	
Standards:		
9-12.ESS3.D.1		
9-12.ESS3.D.2		

21 What kind of weather will nimbostratus clouds likely bring?

A. sunny
B. warm
C. rainy
D. thunderstorms

Master ID:	4073009 Revision:	1
Correct:	C	
Standards:		
9-12.ESS2.D.1		

22 When friction between updrafts and downdrafts within a cumulonimbus cloud creates regions of air with opposite charges, _____ forms.

A. warm air
B. lightning
C. precipitation
D. ozone

Master ID:	4071230 Revision:	1
Correct:	B	
Standards:		
9-12.ESS2.D.1		

23



What does the symbol above represent on a weather map?

A. Occluded front
B. Stationary front
C. Cold front
D. Warm front

Master ID:	4073080 Revision:	1
Correct:	C	
Standards:		
9-12.ESS3.D.1		

24 Near the latitudes 30º north and south the air sinks due to the trade winds and creates an area of high pressure. Many of Earth's major _____ are located here due the the high pressure.

A. Tropical rain forests
B. Temperate forests
C. Polar tundras
D. Deserts

Master ID:	4073075 Revision:	1
Correct:	D	
Standards:		
9-12.ESS3.D.1		

Directions: Answer the following question(s).

25 Name **three** things necessary for the formation of thunderstorms?

A. Moisture
B. Rising air
C. Instability
D. Sinking air
E. Cooling air

Master ID:	4073064 Revision:	2
Correct:	ABC	
Standards:		
	9-12.ESS3.D.1	

26 Name the type of cloud below.



A. cirrus clouds
B. stratus clouds
C. cumulus clouds
D. cumulonibus clouds

Master ID:	4073101 Revision:	1
Correct:	A	
Standards:		
	9-12.ESS3.D.1	

27 Which statement about hail is correct?

A. It may be sent up in the clouds many times.
B. It is rain that falls through a layer of freezing air.
C. It forms in winter in low stratus clouds.
D. It is a liquid form of precipiation.

Master ID:	4073097 Revision:	1
Correct:	A	
Standards:		
	9-12.ESS3.D.1	

28 A short term climatic event in which a band of unusually warm ocean temperatures develops along the coast of South America and can effect global weather patterns is known as _____.

A. La nina
B. El nino
C. A tropical cyclone
D. Trade winds

Master ID:	4073094 Revision:	2
Correct:	B	
Standards:		
	9-12.ESS3.D.1	

29 Which of the following are hazards brought by severe thunderstorms. **Select all that apply.**

A. Stong winds
B. Hail
C. Tornadoes
D. Flooding
E. Lightning
F. Clear blue sky

Master ID:	4073090 Revision:	2
Correct:	ABCDE	
Standards:		
	9-12.ESS3.D.1	

APPENDIX G

MISSOURI HIGH SCHOOL SCIENCE STANDARDS

Missouri Earth and Space Sciences Standards

ESS1 = Earth's Place in the Universe

9-12.ESS1.A.1

- Develop a model based on evidence to illustrate the life span of the Sun and the role of nuclear fusion in the Sun's core to release energy in the form of radiation.

9-12.ESS1.A.2

- Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

9-12.ESS1.A.3

- Communicate scientific ideas about the way stars, over their life cycle, produce elements.

9-12.ESS1.B.1

- Use Kepler's Law to predict the motion of orbiting objects in the solar system.

9-12.ESS1.C.1

- Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor.

9-12.ESS1.C.2

- Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

ESS2 = Earth's Systems

9-12.ESS2.A.1

- Develop a model to illustrate how Earth's interior and surface processes

9-12.ESS2.A.2

- Analyze geoscientific data to make the claim that one change to Earth's surface can create changes to other Earth Systems.

9-12.ESS2.A.3

- Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

9-12.ESS2.A.4

- Use a model to describe how variations in the flow of energy into and out of Earth's System result in changes in climate.

9-12.ESS2.C.1

- Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

9-12.ESS2.D.1

- Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

9-12.ESS2.E.1

- Construct an argument based on evidence about the simultaneous coevolution of Earth's Systems and life on Earth.

ESS3 = Earth & Human Activity

9-12.ESS3.A.1

- Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

9-12.ESS3.A.2

- Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on economic, social, and environmental cost-benefit ratios.

9-12.ESS3.C.1

- Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

9-12.ESS3.C.2

- Evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and or biodiversity of the ecosystem as well as prevent their recurrences.

9-12.ESS3.D.1

- Analyze geoscientific data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

9-12.ESS3.D.2

- Predict how human activity affects the relationships between Earth Systems in both positive and negative ways.

APPENDIX H

BACKGROUND KNOWLEDGE PRE-CHECK: PLANETS

NAME: _____

BACKGROUND KNOWLEDGE PRE-CHECK

1. How many planets are in OUR solar system? _____

2. List ALL the planets you know that are in our solar system: _____

_____

3. What do you think is a Jovian Planet? _____

_____

4. What would be a Terrestrial Planet? _____

_____

5. What 2-3 rules would define a planet? _____

_____

APPENDIX I

STAR CLASSIFICATION LAB AND FEEDBACK FORM

Name: _____ Astronomy
Date: _____ Period: _____ The Physical Setting: Earth Science

Lab Activity: Classification of Stars

INTRODUCTION:

A star's actual brightness is related to its temperature and size. In the beginning of the 20th Century, two independent astronomers developed a graph of this relationship. This graph has been named the Hertzsprung-Russell (H-R) Diagram after these two scientists.

Stars are classified based upon their luminosity, color, temperature, and size. While the temperature of the star is related to its color, the apparent brightness varies with distance from Earth.

OBJECTIVE:

You will plot the location of stars on the H-R Diagram and determine some of their characteristics.

VOCABULARY:

Star -

Nuclear Fusion -

Hertzsprung-Russell Diagram -

Luminosity -

Kelvin -

Lab Activity: Classification of Stars

PROCEDURE A:

1. Using Data Chart A, plot and label each star's position on the Hertzsprung-Russell Diagram.

2. Using Data Chart B, lightly color in vertical bands on the Hertzsprung-Russell Diagram that represent the temperatures of the stars.
3. In the blank boxes provided on the H-R Diagram, label the location of the following groups of stars using your Earth Science Reference Tables: Main Sequence, Giant, Super Giants, and White Dwarfs.

DATA CHART A

Star	Temperature	Luminosity	Star	Temperature	Luminosity
Sun	5,700	1	Aldebaran	4,000	500
Spica	25,000	50,000	Rigel	11,000	100,000
Bellatrix	18,000	1000	Deneb	8,800	900,000
Beta Centauri	21,000	1,000	Betelgeuse	3,200	100,000
Sirius	9,000	20	Epsilon Indi	4,800	0.1
Vega	9,500	90	Polaris	6,000	5,000
Alpha Centauri A	5,700	5	Barnard's Star	3,100	0.005
Pollux	4,700	75	Altair	7,500	10
Ross 248	2,500	0.0001	40 Eridani B	18,000	0.01
Proxima Centauri	2,800	0.001	Procyon B	8,900	0.001
Beta Carinae	9,500	100	Antares	3,200	7,500

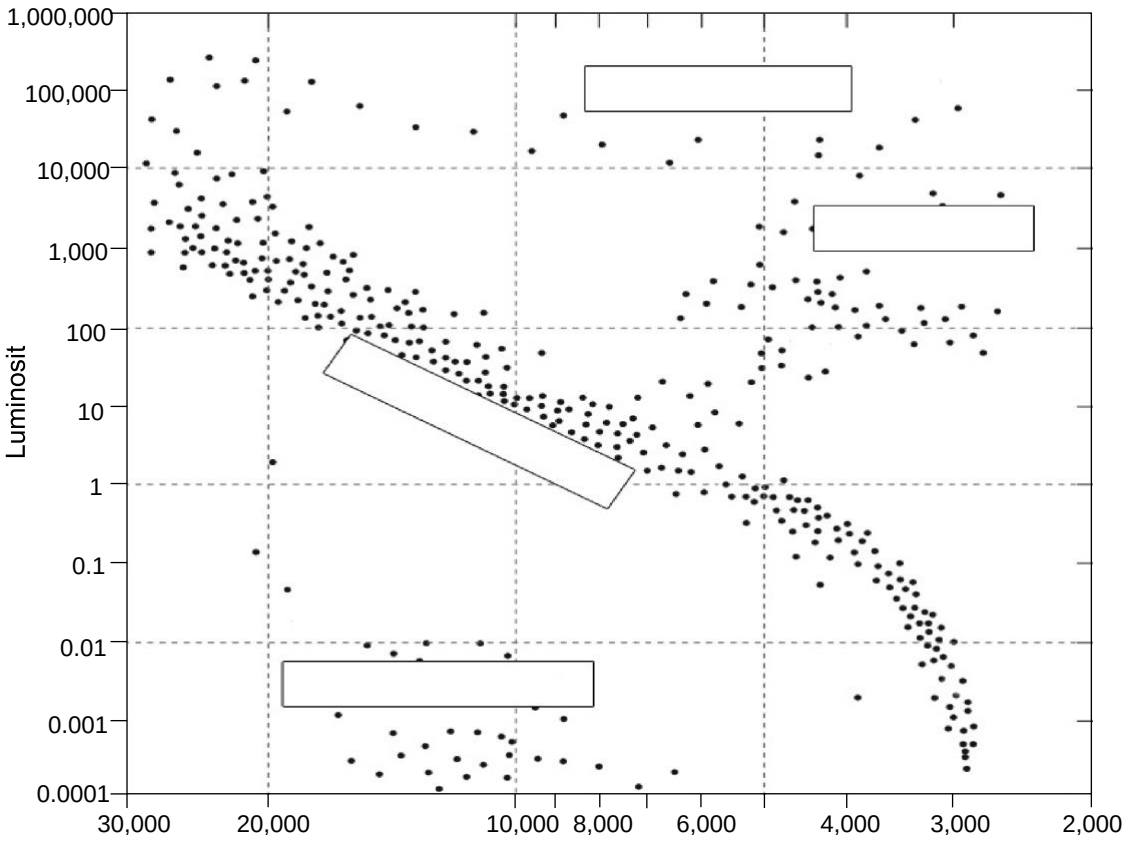
DATA CHART B

Star Temperature	Star Color
2,000 - 3,500	Red
3,500 - 5,000	Orange

5,000 - 7,500	Yellow
7,500 - 11,000	White
11,000 - 30,000	Blue

Lab Activity: Classification of Stars

HERTZSPRUNG-RUSSELL DIAGRAM



Lab Activity: Classification of Stars

DISCUSSION QUESTIONS:

1. Describe the Sun in terms of luminosity, temperature, and color?

2. What is the relationship between star temperature and luminosity in the Main Sequence?

3. What would be the luminosity of a main sequence star with a temperature of 25,000 K?

4. How does a stars color change as its temperature increases?

5. Why do supergiant stars, such as Betelgeuse, have high luminosity?

6. Why do white dwarf stars, such as Procyon B, have low luminosities?

CONCLUSION: How can stars be classified using the Hertzsprung-Russell Diagram?

Lesson Feedback Form

Directions: Please respond honestly and constructively to the questions below by circling the responses you most agree with and writing brief comments.

1. On the scale below, rate the *clarity* of today's session:

1	2	3	4	5
Very Unclear	Somewhat Unclear	Mostly Clear	Very Clear	Extremely Clear

2. Overall, how *interesting* did you find today's lab?

1	2	3	4	5
Very Dull	Somewhat Dull	Mostly Interesting	Very Interesting	Extremely Interesting

3. Overall, how *useful* was today's lab in helping you understand the material?

1	2	3	4	5
Useless	Not Very Useful	Somewhat Useful	Very Useful	Extremely Useful

4. What did you find most helpful about today's class? *(Please list one to two specific examples)*

_____

5. How could the class have been improved? *(Please give one to two specific suggestions)*

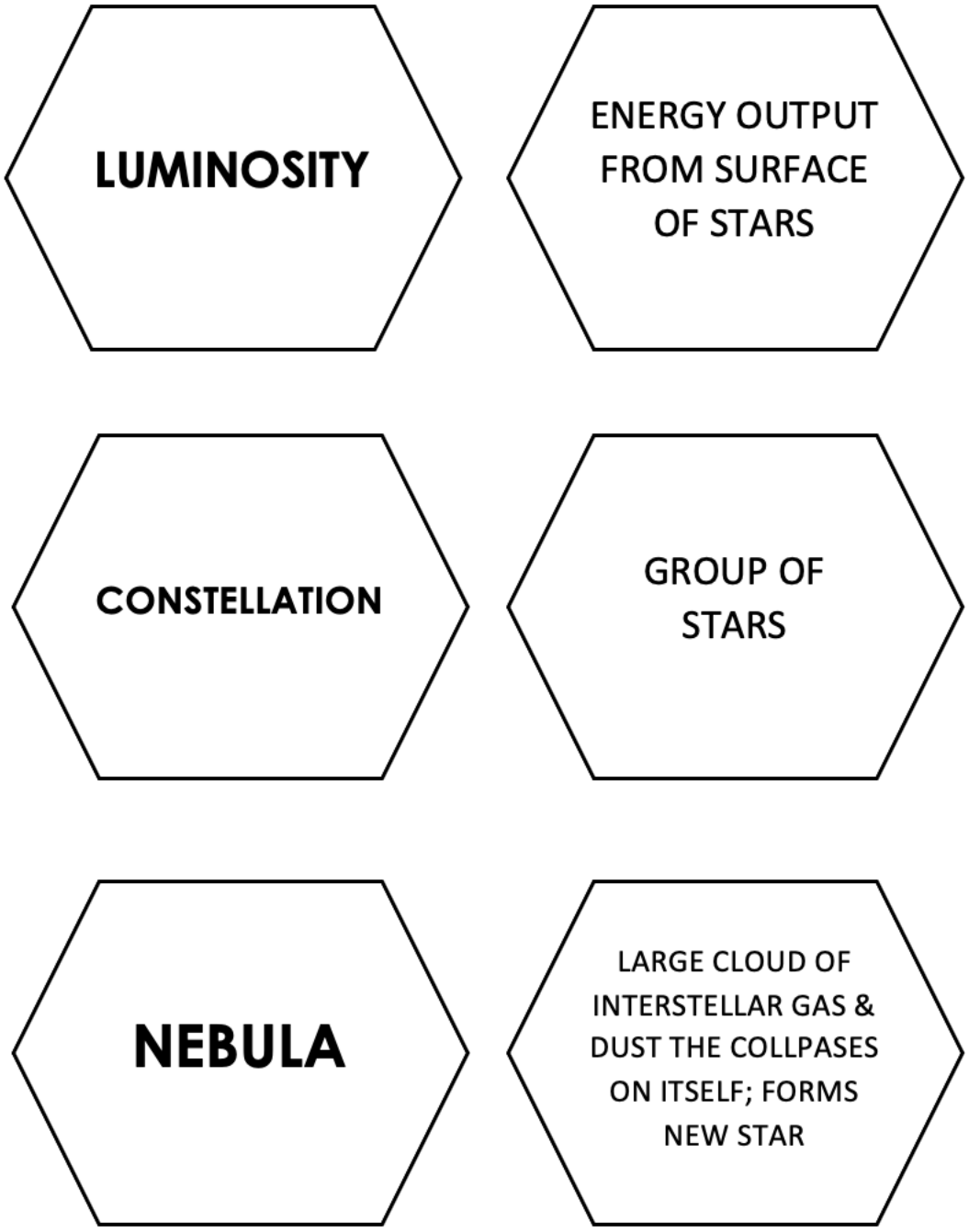
_____

_____

APPENDIX J

SUN AND STARS VOCAB REVIEW AND REFLECTION

Sample of Vocabulary Term + Definition of Activity



NAME: _____ HOUR: _____

SUN & STARS: HEXAGON VOCAB ACTIVITY

Directions: You will use the following vocabulary terms and definitions for all the matching fun

1. You will match EACH term with their CORRECT definition! Once you think you have all your terms and definitions correctly matched, raise your hand and I will check!

Myers Initial _____

2. Now you will ONLY use the terms for this round – move the definitions outta the way! You will match the terms that MATCH together – i.e. you will place "H-R Diagram" and "Main Sequence Star" together. Once you think you've got them all matched together, raise your hand and I will check!
   a. *HINT: You could have 3 separate groups!*

Myers Initial _____

NAME: _____ HOUR: _____

SUN & STARS: VOCAB REFLECTION

Directions: For the following questions, answer honestly about how the activity went!

1. How do you feel you did with the vocabulary matching and definitions? Confident? Need work? Explain.

_____

_____

_____

2. Did you find this activity to helpful in review vocabulary and key concepts? Explain your reasoning.

_____

_____

_____

3. How would you improve this activity for next time?

_____

_____

_____

APPENDIX K

TEACHER REFLECTION JOURNAL: PRE- AND POST-TEST

Teacher Reflection Journal: Pre-Test Data

Unit Test:	Date Given:

Number of Students: _____ Mean Score: _____ High/Low Score: _____

Standards Missed / Need Improvement:

Specific Questions Missed:

Standards Strengths:

Specific Questions Mastered:

Overall Thoughts & Reflections:

Formative Assessment Ideas:

Date Filled Out Form:	Initials:

Teacher Reflection Journal: Post-Test Data

Unit Test:	Date Given:

Number of Students: _____ Mean Score: _____ High/Low Score: _____

Standards Missed / Need Improvement:

Specific Questions Missed:

Standards Strengths:

Specific Questions Mastered:

Overall Thoughts & Reflections:

Ways to Improve Next Time:

Date Filled Out Form:	Initials:

APPENDIX L

STUDENT REFLECTION SURVEY: PRE- AND POST-TEST

Name: _____ Date: _____

Pre-Test Survey

1. How would you rate your performance on the PRE test?

1 – Extremely Poor 2 – Moderately Poor 3 – Moderately Well 4 – Extremely Well

2. Describe how you *feel* you did on the test:

_____

_____

_____

3. How would you rate the topic?

(Unfamiliar = Know nothing of topic, Familiar = Know the topic)

1 – Extremely Unfamiliar 2 – Moderately Unfamiliar 3 – Moderately Familiar

4 – Extremely Familiar

4. What don't you recognize in this topic?

_____

5. What do you recognize / familiar to you?

_____

6. What could help you understand this topic better? (Videos, labs, readings, etc.)

_____

_____

Name: _____ Date: _____

Post-Test Survey

1. How would you rate your performance on the POST test?

1 – Extremely Poor 2 – Moderately Poor 3 – Moderately Well 4 – Extremely Well

2. Describe how you *feel* you did on the test:

_____

_____

_____

3. How would you rate your overall progress in learning this topic?

1 – Extremely Poor 2 – Moderately Poor 3 – Moderately Well 4 – Extremely Well

4. What concepts were still difficult for you?

_____

5. What concepts did you feel you mastered?

_____

6. Is there any way you could have improved on this test? *(Study more, take notes, etc.)*

_____

_____