A Collection of Guided Note-packets and PowerPoint Presentations to be Used in the Earth Science Classroom: With a focus on multi-modal representations and writing in science

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THESIS OR PROJECT ADVISOR: Dr. Peter Veronesi

SECOND READER (if applicable):

PROGRAM ADVISOR:

ANTICIPATED COMPLETION DATE: Spring 2013 (Semester) (Year)

ATTACH THE FOLLOWING:
- Chapter I: Introduction, problem statement, significance of the problem, rationale and definition of terms.
- Chapter II: An outline of the literature review with references.

Approval by Thesis/Project Advisor: __________________________ Date: __________

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Director of Graduate Programs: __________________________ Date: __________
Chapter 1: Introduction

The Next Generation Science Standards, as well as the current Common Core Standards for literacy in science, focus on reading and writing to communicate ideas through scientific practices that promote college and career readiness. Writing in science is conceptualized as a process that develops reasoning, inducts students into the discourse of science, and promotes personal meaning making in relation to scientific explanations (Hand, Prain & Yore, 1999). Traditional understandings of science literacy have a tendency to delude science teachers towards a focus on vocabulary acquisition, laboratory reports, and unintentionally on factual memorization. In order to engage teachers and students in the true practice of constructing knowledge through scientific practices, a multi-modal learning environment needs to be established (Moreno & Mayer, 2007). According to Moreno & Mayer (2007) the challenge lies in the development of multi-modal interactive presentations that encourages the learners need to be cognitively active. This is also supported in Greeno (1997) who makes the claim that representations should be constructed with certain purposes and learning outcomes in mind. Several research papers (Duit & Treagust, 2003, Gilbert, Bulte & Pilot, 2011, Mayer, Heiser & Lonn, 2001) have identified scientific and cognitive process skills that are necessary towards achieving scientific literacy demands. Duit & Treagust (2003) suggested the following five scientific processes as noteworthy skills that should be afforded to learners: (1) recognizing scientifically investigable questions; (2) identifying evidence needed; (3) drawing and evaluating conclusions; (4) communicating valid conclusions; and (5) demonstrating understanding of science concepts. Duit & Treagust (2003) also identified three areas of cross-content competencies; (1) self-regulated learning, (2) ability to solve problems, and (3) communicating and cooperation. Embedding writing strategies into the science classroom can be an effective pathway for promoting learner self-reflection and stimulating cognitive progressions in science classrooms. Prain (2006, p 193) suggests that:

“secondary students need to be able to understand, translate, and integrate these representations as part of learning the nature of science and scientific inquiry, and its languages of representation. By implication, this view of the multiple representational languages of science (visual, verbal, and mathematical) suggests a modified role for written language in the learning process. From this perspective written explanation is seen as only one mode for conceptualization, and increased emphasis might be given to integrating modes or focusing on non-verbal modes.”

In line with other research (Carolan, Prain & Waldrip, 2008, 2010), Schnitz (2002) identifies various visual-spatial representational modes that engage students in task appropriate cognitive activity. Learning outcomes from the merging of visual modes into textual representations are dependent “on the relation between these displays and the task demands and on the learner’s prior knowledge and cognitive abilities (Schnitz, 2002, p. 114).

The implementation of scientific literacy through writing in science can be enhanced through the incorporation of multi-modal note-taking skills, as well as the opportunities for a rich variety of communicative modes of writing within science lectures. The product of this project will be six guided note packets and corresponding PowerPoint presentations that aim to deliver the NYS Physical Setting/Earth Science Core Curriculum through the strategic placement of content, writing prompts, visualizations and multi-modal tasks. Similar to the NYS Earth Science Core
Curriculum, the Guided Note Presentations (GNP) have been developed with the understanding that several different sequences can be employed when applying the NYS Earth Science Core Curriculum within the classroom. As some educators may have a preferred sequence, each note packet is isolated and should be aligned with other units of study as the classroom teacher sees fit. Time constraints urge for a non-linear approach to a curriculum that is linear in organization. The GNP pairs the traditional usefulness of linear note-taking and non-linear note-taking habits, by utilizing an outline pattern for the organization of epistemic and descriptive content and providing templates for depictive and reflective tasks throughout. Examples of non-linear strategies include; concept mapping, diagrams, illustrations and writing prompts. The strategy of each task has been selected to create the most effective platform for visual, audio, kinesthetic, and communicative learners. The selected strategies focus on students fostering their own scientific literacy and communicative skills in a scientific setting.

**Significance of Problem**

After reviewing current research findings on embedding multi-modal representations into science content and curricula the benefits of this methodology far outnumbered the negative effects. Benefits of multi-modal incorporation was researched and affirmed by Atilla, Günel & Büyükkasap, (2010,) Gunel, Hand & Gundtz, (2006,) and Adadan, Irving & Trundle, (2009.) Each of these research projects resulted in an increase in learning outcome scores and student ability to communicate scientific ideas through the implementation of multi-modal representation tasks. The implementation of scientific literacy through writing in science can be enhanced through the incorporation of multi-modal note-taking skills, as well as the opportunities for a rich variety of communicative modes of writing within science lectures.

**Project Design**

This project is designed to be a collection of PowerPoint Presentation based guided note-packets that incorporate science literacy through writing in science practices as well as provide opportunities for students to represent their understanding through multi-modal communication activities. The project will be a collection of six guided note packets for each of the general topics with the NYS Earth Science Standards, created with Microsoft office programs, as well as their accompanying PowerPoint presentation. A fundamental teacher focused aspect of this project is the access to these products as well as the ability to edit as needed for their teaching style and classroom environment. Each multi-modal opportunity afforded in the note-packets will be fully supported and described according to current research and practical methods, the Common Core Standards, and the Next Generation of Science Standards.

Writing in Science representations will include:
- Critical and creative questioning prompts
- Lecture format variation
- Analogies, Metaphors and Similes
- Mnemonics

Multi-modal representations will include
- Student drawn illustrations of mental images
- Mind mapping of ideas and experiences
- Graphic Organizers for review
- Graphic animations from classzone.com within the power point

Monitoring of cognitive processes and assessment of student understanding will be achieved through class discussion and consensus of scientific ideas, accompanied by verbal and written feedback from the teacher. The intent is for there to be multiple opportunities for students to experience several different ways of representing and communicating the nature of science through written and illustrative methods.

Rationale

Time constraints within the Earth Science curriculum and deficient student processing and note taking skills have created a need for me to create a cooperative collection of note-packets to guide students in identifying important concepts. I have been an Earth Science teacher for 7 years in an urban school district and have had a wide range of student abilities within my science classroom. The benefits that guided notes afford regular education students’ is minimized by the advantages that special education students can experience. Students with disabilities that impede their progress in the classroom can benefit from guided notes as they tend to satisfy the concern for cognitive overload. A fundamental affordance that these multi-modal representations allow for is the placement of certain representational and writing tasks as concept review. Research available in my literature review will show positive gains in learning outcomes as well as an increase in social grading systems. These positive outcomes can be caused by an increase in student engagement and metacognition skills necessary for task completion. Another significant aspect of these multi-modal representations and their incorporation into a writing intensive and cumulative note-taking guide is the opportunity for students to edit, assess, and revise their representations based on class communication and scientific consensus. The constructivist approach to knowledge acquisition is dependent on the ability of the reader to build upon prior understanding, creating mental models of student understanding is an excellent way to illustrate misconceptions that might otherwise stay hidden in a verbal representation of prior knowledge. Through the revision and discussion of representative models used in the note-packet, students will be required to identify areas of cognitive change which may encourage students to monitor their own thoughts and understandings within other activities in the science classroom.

Chapter 2: Literature Review

Abstract  The significance of this literature review is to examine the current beliefs and practices that bring scientific literacy into the classroom through writing in science and multi-modal representations. Areas of student intellectual abilities and cognitive processing skills are also examined. Through this review of the educational research, a pattern of significance immerged that supports the implementation of multi-modal guided note-packets in the science classroom. After a thorough review of the research findings, this paper will highlight the
beneficial, and sometimes adversarial, effects of using multi-modal representation in enhancing and exploring scientific literacy and practice, while acquiring note-taking skills.

I. Introduction

II. Theoretical Framework
   i. Writing in Science
   ii. Benefits of guided notes
   iii. Student skills and Cognitive Abilities
   iv. Multi-modal representations in science
   v. Strategies and implications
   vi. Consideration for Implementation

III. Research application
   i. Guided Note Presentations

IV. References
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Leigh W. Trifeletti

Submitted for the partial fulfillment for the requirements of EDI 793

Spring 2013
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**Introduction**

The Next Generation Science Standards, as well as the current Common Core Standards for literacy in science, focus on reading and writing to communicate ideas through scientific practices that promote college and career readiness. Writing in science is conceptualized as a process that develops reasoning, inducts students into the discourse of science, and promotes personal meaning making in relation to scientific explanations (Hand, Prain & Yore, 1999). Traditional understandings of science literacy have a tendency to delude science teachers towards a focus on vocabulary acquisition, laboratory reports, and unintentionally on factual memorization. In order to engage teachers and students in the true practice of constructing knowledge through scientific practices, a multi-modal learning environment needs to be established (Moreno & Mayer, 2007). According to Moreno & Mayer (2007) the challenge lies in the development of multi-modal interactive presentations that encourages the learners need to be cognitively active. This is also supported in Greeno (1997) who makes the claim that representations should be constructed with certain purposes and learning outcomes in mind. Several research papers (Duit & Treagust, 2003, Gilbert, Bulte & Pilot, 2011, Mayer, Heiser & Lonn, 2001) have identified scientific and cognitive process skills that are necessary towards achieving scientific literacy demands. Duit & Treagust (2003) suggested the following five scientific processes as noteworthy skills that should be afforded to learners; (1) recognizing scientifically investigable questions; (2) identifying evidence needed; (3) drawing and evaluating conclusions; (4) communicating valid conclusions; and (5) demonstrating understanding of science concepts. Duit & Treagust (2003) also identified three areas of cross-content competencies; (1) self-regulated learning, (2) ability to solve problems, and (3) communicating and cooperation. Embedding writing strategies into the science classroom can be an effective
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In line with other research (Carolan, Prain & Waldrip, 2008, 2010), Schnotz (2002) identifies various visual-spatial representational modes that engage students in task appropriate cognitive activity. Learning outcomes from the merging of visual modes into textual representations are dependent “on the relation between these displays and the task demands and on the learner’s prior knowledge and cognitive abilities (Schnotz, 2002, p. 114).

The implementation of scientific literacy through writing in science can be enhanced through the incorporation of multi-modal note-taking skills, as well as the opportunities for a rich variety of communicative modes of writing within science lectures. The product of this project will be six guided note packets and corresponding PowerPoint presentations that aim to deliver the NYS Physical Setting/Earth Science Core Curriculum through the strategic placement of content, writing prompts, visualizations and multi-modal tasks. Similar to the NYS Earth Science Core Curriculum, the Guided Note Presentations (GNP) have been developed with the understanding that several different sequences can be employed when applying the NYS Earth Science Core Curriculum within the classroom. As some educators may have a preferred sequence, each note packet is isolated and should be aligned with other units of study as the classroom teacher sees fit. Time constraints urge for a non-linear approach to a curriculum that is linear in organization.
The GNP pairs the traditional usefulness of linear note-taking and non-linear note-taking habits, by utilizing an outline pattern for the organization of epistemic and descriptive content and providing templates for depictive and reflective tasks throughout. Examples of non-linear strategies include; concept mapping, diagrams, illustrations and writing prompts. The strategy of each task has been selected to create the most effective platform for visual, audio, kinesthetic, and communicative learners. The selected strategies focus on students fostering their own scientific literacy and communicative skills in a scientific setting.

*Writing in Science*

Frameworks for instruction are adopted through various standards delineated by state and federal departments of education. Traditional frameworks for creating scientific literacy through writing in science; depicts a student writing reports, recording data, and providing written analysis for assessment. In a more contemporary approach to writing in science, the promotion of student abilities to be cognitive of their habits of mind as they acquire knowledge and are exposed to new ideas is essential. Guided notes provide a platform to explore ways that alternative writing tasks can foster the foundations of contemporary frameworks within the science classroom. The GNP will provide a visual map and allow students to follow and monitor their own thinking processes and learning.

“Science literacy cannot be viewed as stacked facts, skills and attitudes but rather as interacting related dimensions of abilities, habits of mind, knowledge and communication” (Hand, Prain and Yore 1999, p.1032).

College and Career Readiness Anchor Standards, the underpinnings for the standards outlined in the Common Core Curriculum for grades 6-12, address the need for students to be
able to write for many purposes using various formats to be properly prepared for collegiate level performance. As outlined in the common core; students at the secondary level should be afforded the following set of communicative purposes within each grade level; to persuade, explain, and convey experiences. The GNP are supported by the literacy standards set out by the Common Core as well as the foundations set forth in the preface of the NYS Earth Science Curriculum. “It is essential that instruction focus on student understanding and demonstration of the important relationships, processes, mechanisms, and application of concepts.” (NYS Earth Science Curriculum, p.3) The GNP allows students to obtain, record, and evaluate the relationships of earth science concepts. Students can reveal understanding and perception about new ideas and concepts throughout the GNP. Multi-modal communicative tasks serve as an interface between textual/visual information and depictive/mental models. Educators can use these tasks to assess student comprehension using formal and informal evaluation strategies.

Hand, Prain and Yore (1999), designed a unit for a Grade 11 Environmental Science class, to demonstrate the benefits of incorporating three different writing tasks which vary in type, purpose and audience. The writing tasks were developed to encourage the development and exploration of all the dimensions of science literacy. Dimensions of scientific literacy outlined within the unit include; the nature of science, ways of knowing, patterns of argumentation, reasoning, big ideas of science, communications, and evidence. Hand, Prain and Yore (1999), used three phases of development (engage, explore, and consolidate) as a structure for fostering the written communication of scientific ideas. These three phases provide opportunities for students to discuss prior knowledge, investigate new ideas, and collaboratively communicate their new understandings. “Each of these actions is designed to integrate new ideas into their prior knowledge network,” (Hand, Prain and Yore 1999, p. 1028). The writing
tasks provided in series within this unit included a newspaper article, class constructed concept maps and writing for peers assignment, respectively. Although the writing tasks of this assignment utilizes a broader application for the practice of writing in science, then employed within the GNP, it demonstrates a successful framework for promoting each phase of development through different writing and communicative tasks. The framework is designed to enhance the role of scientific literacy, while emphasizing a need for an interactive constructionist approach. An interactive constructionist approach employs an evaluative view of science and promotes knowledge building at the group level.

In another study, Prain (2006) identifies two approaches of current theoretical claims for research on writing for learning in science, epistemic and diversified. The epistemic approach to writing for learning in science focuses on the necessity of learning the system of written scientific discourse in order for students to become scientifically literate. This approach presumes that the most effective way for students to learn through writing in science is to emulate the perceived report writing schemes of professional scientists. The diversified approach has pedagogical justifications as well as a secondary epistemic view of essential scientific literacy acquisition. The pedagogical justifications for a more diversified approach to writing in science is derived from the affordances of multi-modal communication that allow students to explore various purposes, types, and audiences for writing. Writing in this approach is regarded as a resource to enable learners to communicate science concepts using scientific method(s), and practices beyond the classroom. “Students, in attaining scientific literacy, will be able to demonstrate these explanations, in their own words, exhibiting creative problem solving, reasoning, and informed decision making” (NYS Earth Science Curriculum, p.3).
The GNP employs a multi-modal framework of writing in science, with the embedding of reflectionary tasks that focus on the communication of scientific understanding. Student engagement and cognitive activity will increase through everyday language connections and communicative habits. A multi-modal framework includes several different modes of representation that can be used to pursue learning in science. A multi-modal approach to writing for learning in science was employed in creating the GNP. Diversified representations of scientific concepts are presented alongside opportunities for students to explore multi-modal tasks focused on improving scientific literacy and communication. The diversified writing approach, as applied in the GNP, provides conditions for teachers to foster functional student understanding, active engagement and communication.

Anthony, Tippett and Yore (2010) report the preliminary findings from years 1-3 of a 5 year Pacific CRYSTAL Project. The Pacific Centres for Research in Youth Science Teaching and Learning (CRYSTAL) Project based in Canada consists of 15 projects focused around scientific literacy and the scientific community. For years 1-3 of a particular project; 20 middle school science teachers attended 14 professional development sessions aimed to address scientific literacy and a student’s ability to properly communicate their understanding of scientific ideas. The projects approach to scientific literacy is a “holistic view of language in science learning where text is the permanent representation of oral discourse and mental images and includes printed words, symbols, and visuals, acknowledging and integrative and interactive nature of science literacy and constructing understanding,” (p. 47). The results yielded by the three school districts that participated in the study showed an overall increase in both reading and writing assessment test scores as well as an upward mobility of students within the scoring category percentages. Highlighted within the article was a particular aspect of the study which
involved creating brochures to aid in concept communication. Several teachers who attended a professional development on brochure making in for the science classroom also implemented the strategy in their classroom. The study results reported by Anthony, Tippett and Yore (2010), provide evidence that the writing tasks have enhanced instruction and assessment, integrated critical literacy strategies such as writing summaries, and combined visuals with print to encourage and emphasize communication to increase comprehension.

A broader affordance of the brochure project implementation was the flexibility of the task which allowed teachers the opportunity to “adapt the activity to match their personal teaching approaches and at the same time accommodate the learning needs of a diverse group of students,” (Anthony, Tippett and Yore 2010, p. 57). The flexibility of the brochure project is emulated within the GNP, each product is provided in the widely used Microsoft Word and PowerPoint programs. This will afford teachers the ability to modify and add strategies that are more appropriate in their individual classrooms.

Benefits of guided notes

As a relatively new educator, in an urban school district, the necessity for efficient and engaging lecture material was apparent. Note packets created by one David Mills in 2000, provided the content with graphics. However, access to these note packets was scarce and my teaching style and instructional path was overly influenced by the flow of the note packets. To alleviate these uniquely notable obstacles and create a theoretically and research based product, the GNP was developed. The GNP make it possible for teachers to employ various presentation and delivery techniques used to further increase the retention of information. As students are more able to complete notes with fluency an educator may decide to include additional blanks.
This will foster the note-taking and dual audio skills that are needed at the collegiate level. The GNP lends its usefulness to context-based learning strategies. In context-based learning, concepts are framed within a context and relationships between concepts are explored. This method of context-based learning provides educators and students with the answer to the questions of; why should I learn this? (Gilbert, Blute & Pilot, 2001) The pre-questioning strategies used in the GNP can be employed to drive further context development for scientific learning.

Blackwell and McLaughlin (2005) reviewed data-based research to explore the behavioral effects of guided notes and other strategies used to increase student response and engagement. The study reviewed the use of guided notes, choral responding and response cards engagement strategies in various classroom environments. The study concludes that guided notes, as well as alternative multi-modal tasks should be implemented in classroom to increase a student’s likelihood to participate. The instructional affordances provided by the use of the GNP in an Earth Science classroom progresses beyond increased student engagement and understanding.

The benefits that guided notes afford regular education students’ is minimized by the advantages that special education students can experience. In a study conducted by Lazarus (1991), the benefit of guided notes on the achievement of six secondary students with learning disabilities placed in a mainstream content course was explored. The study group consisted of five male students and one female student, ranging in age from 16 years-17 years. Reading and language assessment levels for the six students ranged from 9-2 years and 11-8 years of age, respectively. Each student was enrolled in at least three integrated classrooms. Lazarus found that guided notes, especially when followed up with a review of content, did increase scores, for
both general and special education students. Students with disabilities that impede their progress in the classroom can benefit from guided notes as they tend to satisfy the concern for cognitive overload.

Heward (1994), defined guided notes as “teacher prepared hand-outs that ‘guide’ a student through a lecture with standard cues and prepared space in which to write the key facts, concepts, and/or relationships, as cited in Konrad, Joseph and Eveleigh (2009). Guided notes provide an opportunity to actively engage students in their learning and create a platform for class discussions and explorations. In a meta-analytic review of guided notes, Konrad, Joseph and Eveleigh (2009), find that implementing guided notes in the classroom had a positive effect on content learning as well as note-taking accuracy. A review, of short form verses long form guided note studies, showed that students prefer the short form format that allows for one to three words per blank on the note-sheet. Long form would impose the task of writing four to eight words per blank on the note-sheet.

Metacognition skills necessary for written task completion can be fostered and developed at the group or individual level as the classroom teacher sees fit. Note-taking tasks should be focused on translating scientific language into everyday communicative terms while monitoring and altering the cognitive processes that take place as students’ communication habits and interpretations shift. The level of teacher modification available is what makes the GNP a unique product. As teaching style, classroom dynamics and educational standards change so can the strategies and content within the GNP. The use of guided notes increases student response in the classroom, as well as provide a summary of the lesson and aid in the development of note taking strategies (Blackwell & McLaughlin, 2005.) It is imperative however, that the placement of depictive (visual) and descriptive (textual) modal opportunities as well as affordances provided
by the modes of representation, are implemented through effective and careful planning with a focus on student cognitive load and scientific practices. The sole factor in student comprehension of depictive representation is student engagement in active cognitive processing. The linear aspect of the notes provide students with a trail of connected ideals with multi-modal representations embedded within to enrich recall, retention, and everyday communication.

*Student skill and Cognitive Ability*

The GNP have been created to help teachers address various levels of student abilities and provide students with multi-modal communication outlets. When students become more confident in their cognitive processing skills, they will also become more active in learning to construct and interpret representations. The Common Core Standards state that students should be able to “integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words” (p. 60). As students begin to recognize their own learning habits they can then relate the same habits to those used in the nature of science and scientific reasoning. The advantages of using PowerPoint for a presentation interface includes its cognitively variable features; students have more opportunities to move between and evaluate representations as they observe. PowerPoint presentations, as opposed to summative report writing, provide a more engaging and interactive methods of communication. While summative writing is a helpful tool, it is important to include other modes of communication and representation.

Greeno (1997) discusses 3 ways students can communicated their ideas using representations during a LifeLine curriculum unit; 1) graphics and tables paired with narrative descriptions, 2) qualitative expectations about observed quantifiable relationships, and 3) explicit
description of model results and group consensus (p. 366). The study resulted in positive feedback for using symbolic representation as opposed to technical representation. Greeno (1997) indicates that technical written representation should be preserved as an end product, while symbolic representation is viewed as a way of expressing ones understanding and experience. Students can learn to create their own multi-modal representations, increase the organization of their ideas and inferences and aid in the modification, evaluation, and revision of notes, thoughts and prior knowledge. Pictorial comprehension, as opposed to textual representation, provides an opportunity for students to access higher order cognitive processes due to the immediate perspective imagery that occurs. When creating this type of imagery or mental model the learner will select and sort information according to their prior knowledge, level of importance and conceptual relevancy. Semantic processing is necessary for understanding a picture beyond the interpretive stages. Processing must occur at schema development and reflection levels of cognition. The simultaneous graphic and spatial information provided by a pictorial representation allows the learner to construct and evaluate knowledge using the same inference and reference for cognitive growth. Pictorial comprehension and representations can be developed and deliberated at an individual level that eventually leads to a group collaboration or consensus of the mental model.

Makany, Kemp and Dror (2009) found that non-linear note takers significantly outperformed those who use a traditional linear note taking model. Guided notes allow students to reduce some of their cognitive load by providing them with a template for recording information. Katayama (1997) found that partial notes are more effective than completely filled in notes in aiding students in the transfer of text to knowledge. The transfer of knowledge afforded by partially guided note packets is beneficial to both student and teacher who can
become overwhelmed with the factual, evidentiary discourse that takes place during a science lecture. Larson (2009), provides evidence that teacher productivity might increase if there was a product that combined the benefits of guided notes with the appeal of computer generated graphics presentations. It was also found that skeletal notes, notes with text and blanks, significantly increase recall ability more than when students write their own notes or none at all. The effect of typeface and slide design was also examined in Larson’s study. No significant variation in student recall was attributed to the aesthetics of the presentation. While creating the GNP, students’ opinions were generated to adjust the visual appeal of each presentation design.

Boyle (2010) conducted a study on the note-taking skills of middle school students. Boyle’s study involved 90 students, consisting of 45/45 learning/non-learning disabled students with a 46/44, boy/girl configuration. Students in the study watched a 19 minute video introducing plasma engines, students were allowed to take and study their notes before taking a 10 point quiz on the video. Boyle also conducted a 3 minute speed fluency test to determine a baseline for note quality comparison. Quiz scores were evaluated to assess the students, as well as informal assessments of completion and student feedback of comprehension and format. The study concluded that students with learning disabilities were less likely to pick up on cued and non-cued points, having the time to write less than the students that do not have learning disabilities. It is important to note the abilities of all learners in the classroom when providing guided notes, in an inclusion classroom some students may need to be provided with more guidance than others. As the English Language Learner population increases; guided notes can provide task-focus variations. Differentiation provides ELL students an opportunity to absorb verbal information without the demanding cognitive tasks of listening/reading and writing simultaneously.
Peverly et al. (2007), explore the cognitive processes that promote effective note-taking skills. More specifically the study focuses on three cognitive processes that are related to quality note-taking; transcription fluency, verbal working memory and the ability to identify main ideas. Transcription fluency refers to a student’s rate of written word production. In general, slower transcription fluency is linked with subordinate monitoring of processing in working memory and more inaccuracies in the recall of information from working memory. Other factors that affect note-taking skills and content retention are the cognitive processes involving the verbal working memory. The working memory is a construct of an individual’s reading, writing and verbal abilities. Transcription fluency, working memory, and identifying main ideas are all cognitive skills that can be practiced and enriched through multi-modal communication embedded into guided notes. Notes’ quality was the only independent variable to relate significantly with quality of written recall. As students’ progress and become aware of their cognitive processes, task proficiency, notes’ quality and therefore content retention should improve. The GNP aims at enhancing student comprehension while decreasing the cognitive load associated with intensive writing note-taking tasks.

Note-taking is fundamentally a cognitive overload for students. Guided notes can provide students and teachers with the opportunity to overcome classroom time constraints, while providing a measure for student perception and reflective communication using multi-modal representations. These three affordances aid in reducing the cognitive load of each note taking session and develop a platform for student self-monitoring and awareness of cognitive load and ability. For example a teacher presenting a lecture may decide to allow students a few moments to record missing blanks in their note-packets before beginning to speak or present a focus question to review the new information. Providing this time during the note-taking process
allows students to focus on less cognitive demands at once and provides them an opportunity to evaluate the new ideas based on their previous understandings.

Stenning and Gresalfi (2006) conducted a study aimed at observing the reasoning processes applied while students learn to model computer-based mice population simulations. In this study it is noted that students, when left to create their own model circumvent the methods of the task and proceed with only an end product as the goal. Students in the study appear non-reflective about their end product and except the result under misinformation from calculations, as well as a lack of review or group consensus towards a conclusion. The GNP will aid in training students to monitor and reflect within their learning, so that cognitive practices become a natural and internal propensity. Increasing the cognitive awareness of students affords an enhancement to the experiences that classroom activities are designed to provide. Another method of fostering cognizance would be to have students create concept maps or mind maps; this can begin at an individual level and then developed collaboratively to display group consensus. Piolat, Olive and Kellogg (2005) review the cognitive functions, procedures, strategies and working memory constraints that students encounter as they complete demanding note taking tasks. “Cognitive analysis is even more critical to understanding when it is recognized that note-taking cannot be equated to simply copying what is heard, observed or thought.” (p. 291).

Mayer, Heiser & Lonn, (2001,) have reported findings that identify cognitive constraints of multi-media learning and the adverse effects cognitive overload can have on students in science. In the study the authors assert that too much multimedia material in a presentation will result in less understanding. Four experiments were conducted which manipulated the form and quantity of modes used to present a video on the formation of lightning. A college level student
who watched only the video and did not receive extra modes of communication during the video scored much higher on the comprehension quiz given after the video was viewed. Other modes of communication that were paired with the video included on-screen text, inconsequential but interesting details, and the placement of these details before or after the informational video. In each of these instances additional modes of communication had significant adverse effects on assessment scores. The negative effect on-screen text can have on student comprehension and retention is attributed to the redundancy principal, which duplicates the communication that is already taking place within the video (Mayer, Heiser and Lonn, 2001). In the case of where additional information is best placed, before or after significant information, test results showed that there was small, statistically negligible benefit to view the additional details after the initial information. As a result of the research; when creating a multimodal representation, specifically an animated account, educators should not include information based on student interest alone. This would result in including too much additional non-significant information into a presentation. Mayer, Heiser and Lonn (2001) subscribe to the coherence effect, which states that; “students understand a multimedia explanation more deeply when interesting but conceptually irrelevant video and narration are excluded rather than included (p. 196.)

While students under take the daunting task of note taking, there is simultaneous demand on their verbal, visual, and textual cognitive efforts. Student ability and time constrains within the classroom are influential factors that can levy substantial cognitive demands on students. To facilitate the development of cognitive awareness students should be provided with visual and verbal cues that allow the students to interpret their comprehension of different representational modes. Through the revision and discussion of representative models used in the note-packet, students will be required to identify areas of cognitive change, which may in turn, encourage
students to monitor their own thoughts and understandings within other activities in the science classroom. Obtaining mastery of communication through the negotiation of representational systems is a necessity for learning in science.

**Multi-Modal Representations**

A constructivist approach to knowledge acquisition is dependent on the ability of the reader to build upon prior understanding. Creating mental models of abstract understanding is an excellent way to illustrate student misconceptions that might otherwise stay hidden in a verbal representation of prior knowledge. Modeling how students can interact with their note taking affords them a skill later in collegiate or professional settings, as well as creating a positive learning experience associated with note-taking. Embedding multi-modal representations into guided notes aid in developing note-taking skills while simultaneously nurturing the substance, language, and communication of scientific ideas. These modes can be grouped into categories of visual, mathematical, verbal and kinesthetic representations. Symbols and graphics are much more suitable at expressing quantitative meanings, while verbal language is advantageous when articulating reasoning and relationships. Prain (2006) asserts that there is an agreement among research that each mode of representation has strengths and weaknesses that can affect the learning outcome.

Moreno and Mayer (2007) sought the answer to four questions focusing on multimedia learning environments; 1) what are interactive multimodal learning environments, 2) how do students learn from them, 3) what are the design principles in place, and 4) what implications for future research are there? Interactive multimodal learning environments vary on a spectrum of representational communication, but mainly pair verbal and non-verbal modes. Guided notes
with embedded representational tasks are meant to provide teachers with a vehicle to deliver content while enhancing the communicative skill level and cognitive awareness of the students. This cognitive awareness affords students the opportunity to experience the knowledge building methods that are used in a professional setting.

In secondary classroom settings students are introduced to more complex representations and must acquire the appropriate communication skills in order to participate in their learning. Both scientific and everyday representations should be analyzed during concept building and reflection. This allows students to connect content-specific knowledge to everyday language and ordinary reasoning while constructing meaning in science. Representations should be used during note-taking to promote thinking, questioning and prediction of subject matter. With these things in mind Carolan, Prain and Waldrip (2008) designed the IF-SO framework, which outlines how educators can effectively select and facilitate representational tasks (Figure 1). Identifying key ideas, recognizing form and function, sequencing/scaffolding learning, and ongoing assessment are crucial factors that determine the effectiveness of the task or mode used to communicate an idea. A pedagogical triad model can also be a starting point for choosing which representations to use (Figure 2.)
Waldrip, Prain and Carolan (2010) conducted a study aimed at improving secondary science learning through the use of multi-modal representations. Within this study the authors employed the previously discussed IF-SO framework (Figure 1), which emphasizes the opportunity for negotiation and revision of representations. Peirce’s triadic model of sign systems (Figure 2) is also used or discussed in both studies, as well as the implementation of the IF-SO triadic/pyramidal model. Students seek to create knowledge from new experiences, information, and generative processing. The use of multi-modal representations embedded into guided notes and lecture materials guide the natural process of cognition. Everyday language is crucial to bridging the gap between prior knowledge and new knowledge. This constant and consistent activation of cognitive processes and schema provides an external source of engagement that can cause students to engaged and become more aware of their thinking processes. The use of multi-modal representations; especially student generated models are extremely useful for providing insight into student thought processes as they communicate their understanding of a subject through their representations. The use of student generated representations increases student engagement and enhances reflective opportunities.

Schnotz (2002) discussed the relevance of embedding depictive representations within textual formats with an emphasis on the proper pairing of the visual spatial task with human cognitive processes. Mental representations are a significant process for note-taking effectiveness because they are used in both descriptive and depictive representations. Each type of representation functions off of the same cognitive structural process; surface information, propositional representation, mental models, communication and schema shifts. The cognitive sequence however, is slightly modified, since learners cognitive subsystem differs while developing mental models within each representational modality. Using depictive representations
before providing the descriptive counterpart activates the learners’ mental models first, before employing a propositional representation. Since depictive representations demand less of the working memory they are best placed before textual tasks which will demand more attention and place higher demands on cognitive tasks. Pictures are beneficial to the cognitive processes that take place during note-taking tasks, as they provide a vehicle for information transformation. This advantage has been attributed to the fact that visual displays are interpreted with both imaginative and verbal cognitive processes. This minimizes the cognitive load on working memory due to an increase in possible cross-connections made with previous schema and new knowledge. The dual cognitive processes create an opportunity to use integrative procedures that allow learners to connect illustrative representations to expressive representations.

Comprehension of text is dependent on the learners’ ability to verbally organize information and create mental models using propositional representations within the context of learning. Research calls for an application of visual-textual adjuncts, in which the aim in the GNP is to begin to interweave the theory and research into practice. Linking both the textual and visual aspects of a new concept aids in the communication of information and supports the development and identification of the thinking process. Pictorial depictions can be classified as representation, organization, interpretation, transformation, and decoration (Schnotz, 2002). As concepts and details become more difficult the presence of more visual displays can be beneficial however, too many representations can cause a deficit in learning, lead to misconceptions and affirm misinformation. Students with less prior knowledge on a subject matter and lower verbal skills benefit from additional pictorial displays with textual descriptions. The most effective learning will occur when the relationship between the pictorial display, the task demands, knowledge and cognitive ability has been examined and matched appropriately with cognitive
processes. Verbal and pictorial displays must be coherent and illustrate a semantic overlap with the content. Reflection based on the unification of these two types of displays must be activated within the learners’ schema and driven by the learner's schematic understanding. Knowledge maps provide this opportunity to students as it allows them to interpret and display their understanding and thinking processes through pictorial communication. As the students display and trace their thoughts it allows them to focus on the structural and organizational aspects of knowledge. It is important to note that additional formats of representations (modes) does not yield additional cognitive enhancement. Whether the visual displays are animated or static is inconsequential to student comprehension of depictive representations. Nevertheless, studies have shown that students who are presented with text and create illustrations simultaneously have performed better on problem-solving tests.

Hall, Bailey and Tillman (1997), designed an experiment to test this very claim. Ninety-two college freshmen were given a one-page text describing how a hand air pump works, and then were provided with three different forms of information and instructional tasks. The first group was provided with written specs of an air pump, group two received written and illustrative descriptions, and the last group was provided with written instructions and descriptions and was also told to draw the instructions as they understood them. The study concluded that the third group scored significantly higher on the assessment given about air pumps after the instructions were read. Aside from the beneficial effects on the students’ comprehension and concept retention the activity also provided the instructor to opportunity to determine the nature of a students’ understanding and possible misconceptions. Mind mapping can be a logical way to identify misconceptions and allow students to evaluate their ideas and cognitive systems underlying the misconception. The GNP have been embedded with multi-
modal activities to enhance student communication, comprehension and review of context based representations.

Adadan, Irving and Trundle (2009) studied the impacts of embedding multi-representational communication on students’ conceptual understandings. It was found that 47.8% of students who received multiple forms of representation within their instruction achieved scientific understanding compared to 0% of students who received and communicated with verbal representations. Additionally, 15.8% of single instructional mode students were classified as holding alternative fragments as their conceptual understanding compared to 0% of the multi-representational students. Scientific professionals use models and various forms of representation to communicate their ideas. Students in a science classroom should be encouraged to mimic these strategies. By providing opportunities for students to explore and develop multiple representations, especially for objects and ideas that are normally unobservable and intangible, scientific cognizance and ways of thinking are ultimately exposed. Animation representations can improve the visualization of earth processes that can then be recognized as science in everyday life. More dynamic representations (animations, drawings, etc.) can help students comprehend spatial and variably dynamic relationships within Earth’s systems. Multiple representations lend themselves to differentiating instruction; in that students’ abilities will vary based on the task and modality that is employed. Lowe, Schnotz and Rasch (2011) conducted a study to determine if students could benefit from the intentional matching of animated graphics within contextual tasks. The study found that students were actually negatively affected by the animated graphics. This was attributed to students creating their own mental representations based on what they saw in the video. These students were less likely to correctly sequence the pictorial presentation information. Mayer, Heiser and Lonn’s (2001)
redundancy principle focuses on pairing the correct textual and visual representation with the proper modality of sensory perception. When selecting the correct pairing of text and task educators must consider mental representation as the unique conduit to accomplish or derail specific learning objectives and outcomes.

Atıla, Günel and Büyükkasap (2010) conducted a study in a Turkish 6th grade class. Seventy four students were pre and post tested within a two week period about their understanding of force and motion. Atıla, Günel and Büyükkasap (2010) found that using text and representations while communicating ideas is more beneficial that text only communication. It is important to encourage students to try new modes of representations, especially those that students find more difficult. In a similar study, Gunel, Hand and Gundtz (2006) compare the effects of using multi-modal representations in presentation format verse summary report format for one hundred and thirty-two, male, Turkish, 11th grade students. The students were assigned the task of presenting the ideas of quantum physics to an audience of 10th grade students. Gunel, Hand and Gundtz (2006) found that students preferred PowerPoint as a presentation tool; this is attributed to the visual displays and representational support that can be included in a PowerPoint. After reviewing current research findings on embedding multi-modal representations into science content and curricula the benefits of this methodology far outnumbered the negative effects. Benefits of multi-modal incorporation was researched and affirmed by Atilla, Günel & Büyükkasap, (2010,) Gunel, Hand & Gundtz, (2006), and Adadan, Irving & Trundle, (2009). Each of these research projects resulted in an increase in learning assessment scores and student ability to communicate scientific ideas through the implementation of multi-modal representation tasks. Another significant aspect of these multi-modal representations and their incorporation into a writing intensive and cumulative note-taking
guide is the opportunity for students to edit, assess, and revise their representations based on class communication and scientific consensus. A fundamental affordance that the GNP allows for is the placement of certain representational and writing tasks as concept review. In order to nurture the mastery of multi-modal systems through guided notes, representations should be constructed with specific learning objectives and all skill levels considered.

Summary

Curriculum changes, challenge teachers to bargain with the balance between lecturing notes and hands-on practice. With instructional strategies, especially in the field of science, moving toward inquiry learning, there is less time allotted for content acquisition. However, in secondary science and collegiate classrooms the necessity and function for note-taking increases in intensity. The benefits of employing guided note-packets is evident in the literature and the classroom, where student writing speed and organizational skills vary greatly. The GNP packets provide students with the opportunity to see how notes can be organized and give them a concrete source to study from and find information. The formats selected in this project have been based on a few strategies, from these base strategies students will experience a scaffolding of tasks and skill throughout each note-packet as the content becomes more detailed and multifaceted.

Strategies and Representations

Several design principles were outlined by Moreno and Mayer (2007); guided activities, reflection, feedback, pacing and pre-training. All of these principles are visible throughout the GNP. For more detailed insight feedback refers to type of feedback, where corrective feedback produces less cognitive growth, evaluate feedback provides students an opportunity to explain,
defend and revise their representations or interpretations of the task. Pacing is provided in the note packets by creating a bundled approach to the content, where students are expected to process and reflect on smaller segments of content that will then lead to whole and cross-content connections. Through the employment of these design principles writing in science tasks and multi-modal representations can enhance scientific communication and cooperation during class discussions, lectures and subsequent activities. By means of incorporating prompts for students to explore multiple modes of representation in science note taking skills and closely planning and monitoring for student cognitive engagement during writing tasks; student abilities and attitudes towards affirming scientific ideas through multiple modes of communication will certainly experience a conceptual shift.

Schnotz (2002) examines the benefits of; symbols vs. icons, descriptive vs. depictive, mental representations, textual vs. pictorial comprehension, and feature vs. structure information. Each of these situations will be discussed and evaluated before use within the GNP, to provide a basis for the interpretation and correct pairing of task mode and cognitive processes that would provide the most effective learning. The textual and mathematical portions of the GNP are classified as symbolic or descriptive representations; any pictorial or graphic displays within the note-packets are classified as iconic or depictive representations. When designing the GNP both informational and computational tasks where included. The informational tasks involve the structural process of completing the guided notes. Computational tasks are the multi-modal tasks inserted in appropriate places within the context of the note packet. Linguistic representations have a higher capacity for representational power, where as a depictive representation can appear to be fragmented ideas, put together in series. Depictive representations, as opposed to linguistic representations, are not limited by a written or verbal description and draw upon the learners’
perceptions, interpretations and knowledge construction. Since depictive representations engage learners in developing their own ideas it is important to match graphics appropriately with their descriptive counter parts to avoid visual-textual contradiction and the formulation of misconceptions. The frameworks and dimensions of writing in science that are used within the current research can be applied within the note-taking process, so long as the writing task is correctly paired with the cognitive demand and skill dimension to be performed.

**Consideration for implementation:**

In the era of standards and common assessments it is essential that within the development of the GNP, both the new NYS Common Core Standards and the NYS Physical Setting/Earth Science Core Curriculum were used to implement and incorporate content standards and literacy skills required and outlined within each document. The NYS Earth Science Curriculum was utilized regularly when designing and selecting what content information the lectures are comprised of. It should be noted that while some skill standards may be included within the guided note activities, each note packet is focused on content knowledge comprehension and communication. Additional skill standards should be included in class activities and laboratory explorations to be sure that all skill sets are covered.

Time constraints within the Earth Science curriculum and deficient student processing and note taking skills have created a need to create the GNP, a cooperative collection of note-packets, to guide students in identifying important concepts. Five major educational problems can be moderated by the implementation of guided note packets; curriculum overload, fragmented content, incoherent transfer of knowledge, lack of relevance, and no concrete reason to learn (Gilbert, Bulte and Pilot, 2011). The GNP aims to alleviate these five problems, by providing a clear path through the NYS curriculum via 6 earth science units, as well as consistent
checks for interpretation, reflection and communication. Embedding multi-modal communicative tasks within the GNP presents a mouthpiece for the transfer of knowledge and encourages student engagement. Facilitating multi-modal explorations during key lecture points provides students with an opportunity for interpretation, clarification, reflection and revision of prior and new knowledge. In order to enhance and draw out the best learning outcomes for each task there was careful consideration as to the pairing of each textual idea with their multi-modal counterpart. To provide the option of choice students may occasionally be provided with several different modes of communication to choose from, in this instance students will most likely choose the task they are most comfortable with. It is the educators’ responsibility to guide students to develop new cognitive skills and process and should encourage student to try to communicate using various representations.

When pairing descriptive and depictive representations and comprehension tasks there are multiple interactive affordances that may take place, it is important for the educator to identify and choose the most effective interactions and provide structure and balance that guides students through cognitive processes and the related tasks. For example, propositional thoughts should be complemented by the mental model that is produced. To achieve this, educators should identify for students the difference between feature and structural information on a page or slide as addressed in the unit. A structural breakdown will allow students to become familiar with the outline format, which can be used to create review material when the hierarchy of information is better understood. Features in the note packet can be separated into key ideas, major understandings, and supplemental information. It is important to highlight the contrasting characteristics of all features within the GNP. Students should be provided with a structural basis for analyzing textual and visual information for the goal of communicative discourse. Each
feature or task interacts with different cognitive processes and communicative skills to guide students through the transfer of knowledge. The necessity for the pictorial displays may be weaned from the note-packets. In this instance students should be creating their own drawings from the interpretation of the text. Where this is already embedded in the GNP, a careful pairing of task, mode, and desired learning outcomes was considered. While the use of graphics is represented within the GNP the benefits of graphic representation can be lost on the learner if no communication has properly taken place about the relationships within the concept.

In order to best utilize the GNP students should be introduced and trained on the nature of guided note-taking, as well as provide several opportunities for practice and review. The level of guidance and multi-modal opportunities afforded within the note-packet should be adjusted for student skill levels and should focus on developing a reflective student who communicates his/her own ideas after review of new information. Teacher should aid and train students to recognize the cognitive habits that will assist in information acquisition while fostering multi-modal communication skills. It would be a beneficial strategy at the beginning of guided note training sessions to measure student transcription fluency. This can be done by creating a short sentence or phrase for the students to copy down as you time their work, or monitor completion and correctness as a more informal assessment of fluency rate. Peverly et al. 2007 presents and discusses several tests that can be used to assess processing skill levels. Skill levels should be determined before guided note scaffolding is decided. Supplemental engagement techniques in a classroom with students that have learning disabilities may include blank spaces that are strategically places so that by filling in the words students complete a short descriptive phrase.

Every teacher lectures or gives notes to their students in their own way, and when pre-generated presentations are used teachers are stuck with the outlook and opinion of the generator.
The GNP is at its most basic level and is meant to be improved upon by others for substance or learning modification. I submit that facilitators should adjust the amount of prompts with the skill level, grade level and content knowledge of the classroom in mind. It is for this reason that the GNP will be available for revision at the following websites; http://goo.gl/y6u41 (revisable,) http://newyorkscienceteacher.com (original form). However, it is important to note, as Konrad, Joseph and Eveleigh (2009) state, “an adequate number of blanks must be distributed throughout the handout to encourage active attending and engagement” (p. 440). Teachers must guide this process and progressively scaffold student skill levels to optimize scientific understanding and communication.
Guided Note Presentations

Minerals & Rocks

<table>
<thead>
<tr>
<th>Strategy: Activating Cognitive Schema</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong> Descriptive, Pictorial</td>
</tr>
<tr>
<td><strong>Rational:</strong> As students explore what they know about a new topic and how they may identify with it, they are required to activate the schema necessary to continue learning about the topic at hand. This strategy creates a pathway for deeper understanding and learning, as ideas are scaffolded throughout the notes. By activating prior knowledge and communicating that knowledge in several different ways students learn to reflect on their understanding of the topic before it is introduced.</td>
</tr>
<tr>
<td><strong>Location(s):</strong> Page 1, Slide 2</td>
</tr>
<tr>
<td><strong>Reference:</strong> Thinking Questions; Kagan (1999)</td>
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</table>

<table>
<thead>
<tr>
<th>Strategy: Summative Cognitive Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong> Descriptive, textual/pictorial</td>
</tr>
<tr>
<td><strong>Rational:</strong> Throughout the note-packets students are asked to copy and create several drawings. Summative descriptive strategies provide students with the opportunity to combine the main ideas and drawings from within the lecture; into a cohesive statement of understanding. Through this process students and teachers can monitor how students make connections between new ideas and previous knowledge. These strategies provide insight into student comprehension and perception of segmented and holistic scientific systems and processes.</td>
</tr>
<tr>
<td><strong>Location(s):</strong> Page 6, Slide 26</td>
</tr>
<tr>
<td><strong>Reference:</strong> Thinking Questions; Kagan (1999)</td>
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<tr>
<td><strong>Strategy:</strong></td>
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<tr>
<td>---------------</td>
</tr>
<tr>
<td><strong>Modes of Communication:</strong></td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
</tr>
</tbody>
</table>
| **Location(s):** | Page 11, Slide 43  
Page 14, Slide 54  
Page 17, Slide 62  
Page 18, Slide 65,66  
Page 19, Slide 65, 67 |
Thompson & Thomason (1999) |

<table>
<thead>
<tr>
<th><strong>Strategy:</strong></th>
<th>Visual Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Descriptive, pictorial, iconic</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>Visual representations are meant to provide students with an illustration of an idea or word without demanding more from their working memory. Visual-descriptive strategies allow students to illustrate properties of an idea, rather than focus on the textual information. Student perceptions of the concept and its properties are prominent in this strategy. Teachers should allow students opportunities to revise or add to images created during note taking.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
<td>Page 2, Slide 11, 12, 13</td>
</tr>
<tr>
<td><strong>Strategy:</strong> Visual Interpretation</td>
<td></td>
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<tr>
<td>------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Modes of Communication:</strong> Depictive, pictorial, symbolic</td>
<td></td>
</tr>
<tr>
<td><strong>Rational:</strong> Focusing on the textual information provided within the notes students create mental and physical images. The visual-depictive strategy will aid in the creation of mental models as note taking occurs. In each instance the student is asked to interpret the text and create an illustration that depicts their understanding. This creates an internal connection between the student and the concept, as well as supporting informal assessment techniques.</td>
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<td><strong>Location(s):</strong></td>
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<tr>
<td>Page 4, Slide 20</td>
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<td>Page 5, Slide 21 &amp; 22</td>
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<tr>
<td>Page 9, Slide 35</td>
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<td>Page 15, Slide 56</td>
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<table>
<thead>
<tr>
<th><strong>Strategy:</strong> Mathematical Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong> Depictive, pictorial, symbolic</td>
</tr>
<tr>
<td><strong>Rational:</strong> Mathematical-symbolic strategies focus on the development of simple graphic images to represent the relationships between two or more variables. The development of each instance varies from linear to axial locations and labels. Each variation was chosen to draw the attention to the specific variables and how each behaves in relation to one another. Students and teachers should engage in scientific discourse as the relationships are identified and represented.</td>
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<td><strong>Location(s):</strong></td>
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<td>Page 10, Slide 39</td>
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<td>Page 13, Slide 50</td>
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</tbody>
</table>
Minerals & Rocks

I. Minerals are -

1. __________ occurring.

2. Inorganic- No organic matter; ______________________________________________________________________
or the remains of living things.

3. Solid - ______________________________________________________________________________________
definite __________

4. Definite ______________________________________________________________________________________

5. Definite ______________________________________________________________________________________

   a) Examples:

      (1) Graphite - _______________________________________________________________________________

      (2) Sulfur - _______________________________________________________________________________

      (3) Talc - _______________________________________________________________________________

A. Chemical Composition:

1. Minerals are classified into 2 major classes.

   a) ______________________________________________________________________________________

      - minerals that have silicon and oxygen

      groupings; __________.

      (1) combined __________ one or more ____________

      ➤ Talc - Mg3Si4O10(OH)2

      (2) Largest group of minerals

      (a) __________ the earth's ____________.
b) Silicate - minerals that

(1) into several other classes

(a) native - gold, sulfur, silver
(b) - galena, pyrite
(c) - gypsum
(d) - hematite, magnetite
(e) - halite, fluorite
(f) - calcite, dolomite

(2) Extremely rare; 0% of the Earth's crust

(3) Few are relatively common, such as calcite.

B. Crystal Structure:

1. A minerals

2. Atoms and molecules are arranged in geometric .

3. basic crystal systems/patterns

a) / isometric: Galena, Halite, Pyrite

b) : Chalcopyrite

c) : Quartz, Calcite

d) : Olivine, Topaz

e) : Mica, Gypsum

f) : Feldspar, Turquoise
4. Minerals form when...
   a) Lava or _________ cools to ______________________
   b) Water ___________ and leaves minerals behind.
   c) ____________ becomes supersaturated with mineral particles;
      ______________ will ______________ out of the water and
      ______________ as a precipitate.

C. Identifying Minerals: pg _____ of ESRT

1. Minerals can be ______________________ their physical and chemical
   ________________________________.
   a) Physical Properties: Color ___________
      ____________________________
      Cleavage ____________________________
      Density ____________________________
   b) Chemical Properties: ___________________________ mineral

2. Color: Not a reliable property; some minerals ______________________

   a) Color may ___________ due to
      (1) Natural ____________________________
      (2) Weathering: ____________________________
   b) Malachite - ____________________________
   c) Quartz - ____________________________
   d) Sulfur - ____________________________
   e) Hematite - ____________________________

3. Streak: The color of a mineral in its ____________________________.
   a) Determined by using a ____________________________
      (1) Quartz - ____________________________
      (2) Hematite - ____________________________
4. Luster: The way a mineral

   a) Metallic - Reflects light like a ____________________________

      (1) ____________________________

   b) Nonmetallic - Reflects light in more subtle ways

      (1) Pearly - ____________________

      (2) _________________ - Quartz

      (3) Dull/ _____________ - Bauxite

      (4) _________________ - Talc, gypsum

      (5) Brilliant - ____________________

5. Hardness: A measure of ________________________________________

   a) Determined by a minerals ________________________________;

      strength of the bonds and crystal shape.

   b) When a mineral is scratched by a substance, that mineral is said to be

      _____________ than the substance.

   c) When a mineral scratches a substance, that mineral is said to be

      _____________ than the substance.

   d) Moh’s Hardness Scale –

      | Common Objects | Hardness | Name of Mineral |
      |----------------|----------|----------------|
      | 2.5 ____________ | 1 Talc   |
      | 3.5 Copper       | 2 Gypsum |
      | 4.5 ____________ | 3 Calcite|
      | ___________ Glass | 4 Fluorite|
      | 6.5 Steel File | 5 Apatite|
      | ____________ | 6 Feldspar|
      | 7 ____________ | 7 Quartz |
      | 8 ____________ | 8 Topaz  |
      | 9 ____________ | 9 Corundum|
      | 10 ____________| 10 Diamond|
6. Cleavage: When a mineral splits/__________________________

__________________________

(a) Mica - one direction; in a ____________ shape.

(b) Galena - Three directions; in a ____________ shape.

a) Determined by atomic ________________ of minerals.

(1) __________________ is the way a mineral breaks.

(2) __________________ is formed as the crystal grows.

7. Fracture: When a mineral breaks ______________ into curved or

__________________________

__________________________

a) Examples: ______________, bauxite, hematite, ______________

8. Density or ____________ - Minerals have different ______________, and

vary in weight given the same sample ____________.

9. Chemical Properties:

a) Effervescence:

(1) Calcite- reacts with ___________; producing ______________

b) ________________:

(1) Reaction between Iron (Fe) and the ______________ in the air

(a) Example: ________________

(2) Reaction between copper and air; causes a ______________

discoloration.

(a) Example: ________________

10. Special Properties:

a) Lodestone- Magnetite: naturally ______________

b) Iceland Spar- Calcite: produces double ______________

c) Pitchblende: __________________
D. Uses of Minerals:

1. Ore - A mineral that contains __________ and ______________, that can be ______________ and removed in ______________ amounts; for a profit.
   
   a) Metals - elements with ______________ surfaces, are able to conduct __________ and ______________, and are ______________.
      
      (1) ______________ - Hematite/Magnetite
      (2) ______________ - Bauxite
      (3) ______________ - Chalcopyrite/Malachite
      (4) __________ - Gold

   b) Nonmetals - Elements that have __________ surfaces and are __________ conductors of heat and ______________ and are __________.
      
      (1) Halite - ______________
      (2) Gypsum - ______________
      (3) Calcite - ______________
      (4) Koolinite - ______________

2. Alloy - A mixture of two or more ______________ or a mixture of ______________.
a) Tin + ____________ = Bronze

b) Copper + Zinc = ____________

c) Iron + Chromium + ____________ = ____________

d) Lead + Tin = ____________

3. Gems – Minerals that have ___________________________; such as hardness, ____________, luster, ____________, rarity...
   a) Precious Stones: ________________________________
   b) Semi-precious Stones: ____________________________
   c) Gems that are not minerals: ________________________

E. Minerals and Rocks:

1. Many kinds of __________________ are ____________________________
   a) Ex: ____________________________; ____________, feldspar and ____________.

2. Mono-mineralic – Rocks that are composed of only ____________________________.
   a) Ex: ____________________________ is only composed of ____________.

3. Poly-mineralic – Rocks that are composed of ____________________________ minerals.

4. There are approximately ____________ different ____________________

**Common Rock Forming Minerals**

- Quartz
- Potassium Feldspar
- Plag-Feldspar
- Pyroxene
- Amph/Hornblend
- Biotite Mica
- Clays
- Olivine
- Other
II. Rocks are - ________________ based ______ their method of ________________.

A. There are _____ different rock ____________.
   1. ________________
   2. ________________
   3. ________________

B. Sedimentary Rocks: form in __________________________;
   from the accumulation of _______________________, organic matter or chemical precipitate.
   1. Usually form ___________________ in lakes, seas or oceans.
   2. Mostly composed of quartz, feldspar and ____________.

   ![Diagram of sedimentary rocks]

Layers of ________________
   Pressure/weight ________________ and squeezes lower layers.
   accumulate ________________ and ________________ into rock.

3. Types of Sedimentary Textures: pg _____ of ESRT's
   a) ________________: form from mineral ________________ and ________________ that are ________________ and ________________ together. (Lithification)

   (1) Compaction: ________________ by the weight of overlying rock
   (2) Cementation: ________________ by natural cements in water. (calcite)
### Inorganic Land-Derived Sedimentary Rocks

<table>
<thead>
<tr>
<th>Texture</th>
<th>Grain Size</th>
<th>Composition</th>
<th>Comments</th>
<th>Rock Name</th>
<th>Map Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clastic</td>
<td>Pebbles, cobbles,</td>
<td>Mostly quartz,</td>
<td>Rounded fragments</td>
<td>Conglomerate</td>
<td>![Symbol]</td>
</tr>
<tr>
<td>(fragmental)</td>
<td>and/or boulders</td>
<td>feldspar, and clay minerals;</td>
<td>Angular fragments</td>
<td>Breccia</td>
<td>![Symbol]</td>
</tr>
<tr>
<td>Sand</td>
<td>embedded in sand,</td>
<td>may contain fragments of other rocks</td>
<td>Fine to coarse</td>
<td>Sandstone</td>
<td>![Symbol]</td>
</tr>
<tr>
<td>(0.2 to 0.006 cm)</td>
<td>silt, and/or clay</td>
<td>and minerals</td>
<td></td>
<td></td>
<td>![Symbol]</td>
</tr>
<tr>
<td>Silt</td>
<td></td>
<td>Clastic</td>
<td>Very fine grain</td>
<td>Siltstone</td>
<td>![Symbol]</td>
</tr>
<tr>
<td>(0.006 to 0.0004 cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>![Symbol]</td>
</tr>
<tr>
<td>Clay</td>
<td>Clay</td>
<td>Compact; may split</td>
<td></td>
<td>Shale</td>
<td>![Symbol]</td>
</tr>
<tr>
<td>(less than 0.0014 cm)</td>
<td></td>
<td>easily</td>
<td></td>
<td></td>
<td>![Symbol]</td>
</tr>
</tbody>
</table>

b) ___________________________ /crystalline: form from minerals ________

in water, which settle-out or ___________________________

(1) Dissolved ____________________________________________

are ____________________________

after water evaporates.

### Chemically and/or Organically Formed Sedimentary Rocks

<table>
<thead>
<tr>
<th>Texture</th>
<th>Grain Size</th>
<th>Composition</th>
<th>Comments</th>
<th>Rock Name</th>
<th>Map Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalline</td>
<td>Varied</td>
<td>Halite</td>
<td>Crystals from chemical precipitates and evaporites</td>
<td>Rock Salt</td>
<td>![Symbol]</td>
</tr>
<tr>
<td></td>
<td>Varied</td>
<td>Gypsum</td>
<td></td>
<td>Rock Gypsum</td>
<td>![Symbol]</td>
</tr>
<tr>
<td></td>
<td>Varied</td>
<td>Dolomite</td>
<td></td>
<td>Dolostone</td>
<td>![Symbol]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bioclastic</th>
<th>Microscopic to coarse</th>
<th>Calcite</th>
<th>Cemented shell fragments or precipitates of biologic origin</th>
<th>Limestone</th>
<th>![Symbol]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Varied</td>
<td>Carbon</td>
<td>From plant remains</td>
<td>Coal</td>
<td>![Symbol]</td>
</tr>
</tbody>
</table>
4. Sedimentary Rock:

a) Composed of \( \text{___________, mineral or } \), \( \text{___________} \).

b) Can contain a wide \( \text{___________} \) of \( \text{___________} \).
   
   (1) Pebbles, cobbles, boulders, in a sand, silt or clay matrix.
   
   (a) \( \text{___________} \) : rounded fragments
   
   (b) \( \text{___________} \) : angular fragments.

c) Can contain a \( \text{___________} \) sediment \( \text{___________} \).

   (1) \( \text{___________} \) : 0.2 cm \( -0.006 \) cm; fine to coarse sand.

   (2) \( \text{___________} \) : 0.006 cm \( -0.0004 \) cm; very fine silt.

   (3) \( \text{___________} \) : less than 0.0004 cm; minute clays

d) Can be organic and may contain \( \text{___________} \).

   (1) Limestone, sandstone, \( \text{___________} \)

e) Generally are formed in \( \text{___________} \) rock layers; called

   \( \text{___________} \).
C. Igneous Rocks: form from the ____________ and ________________ of molten lava or ________________.

1. When molten _________ or magma cools and solidifies, the ________________ of different minerals form.

2. The rock contains a crystalline structure of ________________ crystals of different ____________, _________ and ________________.

3. Types of ________________ rocks: based on the origin of formation

a) ________________ /Volcanic: form from the ________________ cooling of ________________ on or near the Earth’s ________________.

   (1) Rapid cooling ________________ allow time for crystals to ________________.

   (2) Volcanic rocks have ________________ to ________________; giving it a smooth/_________ texture.

<table>
<thead>
<tr>
<th>EXTRUSIVE (Volcanic)</th>
<th>Obsidian (usually appears black)</th>
<th>Basaltic glass</th>
<th>Pumice</th>
<th>Vesicular rhyolite</th>
<th>Vesicular andesite</th>
<th>Vesicular basalt</th>
<th>Rhyolite</th>
<th>Andesite</th>
<th>Basalt</th>
<th>Granite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Glassy</td>
<td>Non-vesicular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vesicular (gas pockets)</td>
<td>Fine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRUSIVE (Varying)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Granite</td>
<td>Diorite</td>
<td>Gabbro</td>
<td>Peridotite</td>
<td>Diopside</td>
<td>Coarse</td>
<td>Non-vesicular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>1 mm</td>
<td>10 mm</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pegmatite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) ________________ /Plutonic: form from the ________________ cooling of ________________ within the Earth.

   (1) Slow ________________ allows time for ____________ crystals to grow.

   (2) Plutonic rocks have ________________ crystals; giving them a ________________ /rough texture.
### Environment of formation

<table>
<thead>
<tr>
<th>Rate of cooling</th>
<th>Grain Size</th>
<th>Texture</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrusive</td>
<td>Very Fast</td>
<td>crystalline</td>
<td>Obsidian Pumice</td>
</tr>
<tr>
<td>(Volcanic)</td>
<td>Fast</td>
<td>Less than 1mm</td>
<td>Basalt Rhyolite</td>
</tr>
<tr>
<td>Intrusive</td>
<td>Slow</td>
<td>1mm or larger</td>
<td>Granite Diorite</td>
</tr>
<tr>
<td>(Plutonic)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**c) Crystal size Vs.**

1. _____________________ in the Earth’s crust _____________________

   the cooling __________ and crystal __________.

**4. Igneous Rock Identification: pg _____ of ESRT’s**

![Scheme for Igneous Rock Identification](image)
a) Mafic vs. Felsic

(1) Felsic – ex: ____________________
   (a) Composition - ______________________________________
   (b) Density - __________________
   (c) Color - __________________

(2) Mafic – ex: ____________________
   (a) Composition - ______________________________________
   (b) Density - __________________
   (c) Color - __________________

HOW ALIKE?

HOW DIFFERENT

WITH REGARD TO

PATTERNS OF SIGNIFICANCE:
D. Metamorphic Rocks: form from ______________________ rocks; (sedimentary, igneous, ______________________) that have been ____________________.

1. Crystals and __________________ are rearranged and form new rocks due to ______________________ with extreme heat (magma) or extreme ______________________ (orogeny).

2. Often found in ______________________ regions; where deeper ______________________ is exposed due to weathering and erosion.

3. Types of Metamorphism:
   a) Metamorphic rocks must experience the following conditions in order to undergo metamorphism:
      (1) ______________________
      (2) ______________________
      (3) ______________________
   b) Contact ______________________
      (1) When rocks undergo metamorphism due to direct ______________________
          with ______________________ or ______________________.
   c) ______________________ Metamorphism
      (1) When rocks undergo metamorphism; due to extreme ______________________
          applied during ______________________ events.

4. Metamorphism Results:
   a) Recrystallization - environments within the crust have ______________________
      temperatures and ______________________ pressure; cause rocks to ______________________
      by recrystallizing the old rock material.
      (1) No true melting occurs; it is called a ______________________
      (2) ______________________
      (3) Chemical Change/ ______________________
      (4) ______________________ / ______________________
5. Types of Metamorphic Rocks:

a) __________________: Rock has mineral crystals arranged in __________________ or parallel __________________.

- Ex: Mineral Alignment (______) & Banding (_______)

Scheme for Metamorphic Rock Identification

(1) Mineral __________________: Minerals join together; but do not form __________________ layers.

(a) Creates a shine or ________________ on the rock
(b) ________________, Phyllite and Schist

(2) Bending: mineral__________________ join and __________________ in ___________________; Gneiss

(a) An ____________________ in _________ and __________________ usually produces __________________ bands of alternating __________________.
(b) Distorted ____________________ : the ___________________ of mineral __________________ due to extreme __________________ exerted on the rock.

b) ____________________/unfoliated: rock __________________

have minerals arranged in __________________; ____________ break in layers/sheets.

(1) Ex: _______________________________
<table>
<thead>
<tr>
<th>Texture</th>
<th>Metamorphic Rock</th>
<th>Original Rock</th>
<th>Rock Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foliated</td>
<td>Slate</td>
<td>Sedimentary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Schist</td>
<td>Metamorphic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gneiss</td>
<td>Igneous</td>
<td></td>
</tr>
<tr>
<td>Nonfoliated</td>
<td>Marble</td>
<td>Sedimentary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quartzite</td>
<td>Sedimentary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anthracite Coal</td>
<td>Bituminous Coal</td>
<td>Sedimentary</td>
</tr>
</tbody>
</table>
The Rock Cycle: pg _____ of ESRT’s

6. ____________________________________________________________;

as shown by the diagram below.

Rock Cycle in Earth’s Crust

[Diagram of the Rock Cycle]

Rock Relationships
MINERALS & ROCKS
WHAT QUALITIES DEFINE A MINERAL?

- In the area provided:
  - Draw, describe, OR provide an example of a mineral.
    - Provide a brief explanation if you choose drawings or examples
  - How could you test if something was a mineral?
    - Is there anything common to all minerals?
I. A mineral is:
   1. A *naturally* occurring,
   2. Inorganic, *(next slide)*
   3. Solid, *(the slide after that)*
   4. That has a definite *chemical composition*, and
   5. A definite *crystal structure*

   1) Graphite – *pencil lead*, batteries
   2) Sulfur – *matches*, fireworks
   3) Talc – Powder, *ceramics*

   ➢ not minerals: cement, steel *(man-made)*
2. INORGANIC - NOT COMPOSED OF ORGANIC MATTER; NOT FROM LIVING THINGS OR THE REMAINS OF LIVING THINGS.

- Coal is NOT a mineral because it comes from plants
- Amber is NOT a mineral because it comes from tree sap
- Pearls is NOT a mineral because it comes from oysters
3. Have a **definite volume and a definite shape.**

- Stable and solid at room temperature

- Mercury is not a mineral because it is liquid at room temperature
CHEMICAL COMPOSITION

Silicate Minerals

a) silicon and oxygen groupings; $\text{SiO}_2$

1) combined with one or more metals
   - Talc: $\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$

2) Largest group of minerals
   - 90% of the earth's crust

Non-silicate minerals

b) DO NOT contain $\text{SiO}_2$

1) subdivided into several other classes

2) Extremely rare
   - 8% of the Earth's crust

3) Few are relatively common
   - calcite
NON-SILICATE SUBDIVISIONS

a) Native **Elements** – elements found in nature in their mineral form.
   - gold (Au), sulfur (S), silver (Ag)

b) **Sulfides** – minerals that contain sulfur ions.
   - Galena (PbS), Pyrite (FeS$_2$)

d) **Sulfates** - minerals which include the sulfate ion (SO$_4^{2-}$).
   - Gypsum (CaSO$_4$·2H$_2$O)
d) **Oxides** - minerals that contain oxygen bonded with one or more metals

- Hematite ($\text{Fe}_2\text{O}_3$), Magnetite ($\text{Fe}_3\text{O}_4$)
- minerals containing (OH) are typically included in this class. (hydrous minerals)
- Portlandite ($\text{Ca(OH)}_2$)

e) **Halides** - minerals with that contain Fluorine, Chlorine, Bromine and Iodine ions.

- Halite ($\text{NaCl}$), Fluorite ($\text{CaF}_2$)
**f) Carbonates** – minerals that contain a carbonate ion, $\text{CO}_3^{2-}$.

- Calcite ($\text{CaCO}_3$), Dolomite ($\text{CaMg(CO}_3)_2$)

- Many more subdivisions; each with chemical similarities
1. The internal structure or arrangement of atoms within a mineral
   - Halite (NaCl)

2. Atoms/molecules are arranged in repeating geometric patterns.
3. SIX BASIC CRYSTAL SYSTEMS

a) Cubic - Galena, Halite, Pyrite

b) Tetragonal - Chalcopyrite

c) Hexagonal - Quartz, Calcite

d) Orthorhombic - Olivine, Topaz
SIX BASIC CRYSTAL SYSTEMS

e) **Monoclinic** – Mica, gypsum

f) **Triclinic** – Feldspar, Turquoise
MINERAL FORMATION

4. Minerals form
   a) When lava or magma cools to solidification

   b) When water evaporates and leaves minerals remain

   c) When water is supersaturated with a mineral; minerals will settle out of the water and deposit as a precipitate.
IDENTIFYING MINERALS

1. Minerals can be **identified** by their physical and chemical **characteristics**.
   a) Physical Properties:
      - Color
      - Streak
      - Luster
      - Hardness
      - Cleavage or Fracture
      - Density
   b) Chemical Properties
      - Specific and **unique for each mineral**

- **Determined by chemical composition and structure**
2. Color: Not a reliable property; some minerals **can be many different colors**.
   a) Color may **vary** due to:
      1) Natural **coloring agents** - impurities
      2) Weathering; **exposure** to the environment
   b) Malachite-**green**
   c) Quartz-clear, **purple**, **white**, grey-brown...
   d) Sulfur-**yellow**
   e) Hematite-**black**, **silver**, reddish brown
3. Streak: The color of the mineral in its **powdered form**.

a) Determined by using a **streak plate**

1) Quartz: **White/colorless**
2) Hematite: **reddish brown**
4. Luster: The way a mineral shines/reflects light from its surface.

a) Metallic: reflects light like the surface of a polished metal
   1) Galena, Pyrite, Graphite, Magnetite...

b) Non Metallic: reflects light in more subtle ways
   1) Pearly-Mica
   2) Glassy-Quartz
   3) Dull/Earthy-Bauxite
   4) Waxy-Talc
   5) Brilliant-Diamond
5. Hardness: A measure of how easily a mineral can be scratched.
   a) Determined by a mineral's internal structure.
   b) When a mineral is scratched by a substance; it is softer than the substance.
   c) When a mineral scratches a substance; it is harder than the substance.
# TESTING HARDNESS

## Mohs Hardness Scale

<table>
<thead>
<tr>
<th>Hardness</th>
<th>Name of Mineral</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Talc</td>
</tr>
<tr>
<td>2</td>
<td>Gypsum</td>
</tr>
<tr>
<td>3</td>
<td>Calcite</td>
</tr>
<tr>
<td>4</td>
<td>Fluorite</td>
</tr>
<tr>
<td>5</td>
<td>Apatite</td>
</tr>
<tr>
<td>6</td>
<td>Feldspar</td>
</tr>
<tr>
<td>7</td>
<td>Quartz</td>
</tr>
<tr>
<td>8</td>
<td>Topaz</td>
</tr>
<tr>
<td>9</td>
<td>Corundum</td>
</tr>
<tr>
<td>10</td>
<td>Diamond</td>
</tr>
</tbody>
</table>

**Common Objects**

- 2.5 **Fingernail**
- 3.5 **Copper**
- 4.5 **Iron Nail**
- 5.5 **Glass**
- 6.5 **Steel File**
- 7 **Streak Plate**
6. Cleavage: When a mineral splits/breaks along smooth flat surfaces
   a) Mica - One direction; sheet
   b) Galena – Three; cubic shape

   a) Determined by atomic structure of mineral
      1) Cleavage is the way a mineral breaks
      2) Crystal Shape is the way crystal grows
7. Fracture: When a mineral breaks unevenly into curved or irregular pieces with a rough and jagged surfaces.

a) Sulfur, bauxite, hematite, quartz
 PHYSICAL PROPERTIES

8. Density or **Heft**: Minerals have different **densities**, and vary in weight given the same sample **size**.

   - How heavy the mineral feels in your hand
CHEMICAL PROPERTIES

a) Effervescence
   1) Calcite reacts with HCl; bubbles of CO₂

b) Oxidation:
   1) Reaction between Iron (Fe) and oxygen (O₂).
      a. Iron (Fe) + oxygen = Rust
         ➢ Metal is weakened by change

   2) Reaction between copper and air; creates a greenish coating
      a) Copper (Cu) + oxygen = copper oxide
         ▪ metal is not weakened; pennies
a) Lodestone - Magnetite; is naturally magnetic

b) Iceland Spar - Calcite; produces double refraction

c) Pitchblend; radioactive
WHAT WOULD IT FEEL LIKE TO BE A MINERAL BEING TESTED?

In the area provided

- Provide a written response to the question above
  - You may choose to write about two or more mineral tests

- Include an answer to the following
  - By which mineral property would you want to be identified by? Why
  - Which property would you not want? Why
USES OF MINERALS

1. Ore - A mineral that contains **metals** and **nonmetals** that can be **mined** and removed in **usable** amounts; for a profit
   a) Metals - elements that have a **shiny** surfaces, are able to conduct **heat** and **electricity**, and are **malleable**.
      1) Iron - Hematite/Magnetite
      2) Aluminum - Bauxite
      3) Copper - Chalcopryite/Malachite
      4) Gold - Gold
USES OF MINERALS

b) Nonmetals- Elements that have **dull** surfaces and are **poor** conductors of heat and **electricity** and are **brittle**.

1) Halite(NaCl)- **Salt**
2) Gypsum-Drywall, **chalk**
3) Calcite-**Cement**
4) Kaolinite-**Bricks**
USES OF MINERALS

2. Alloy - A mixture of two or more metals or a mixture of metals and nonmetals
   a) Tin + Copper = Bronze
   b) Copper + Zinc = Brass
   c) Iron + Chromium + Limestone = Steel
   d) Lead + Tin = Pewter
USES OF MINERALS

3. Gems - Minerals that have desirable qualities; such as hardness, color, luster, clarity, durability, rarity...
   a) Precious Stones:
      - Diamond, Rubies, Sapphires, Emeralds
   b) Semi-Precious Stones:
      - Amethyst, Garnet, Topaz
   c) Gems that are not minerals
      - Pearls, Amber
ROCKS IN RELATION TO MINERALS

1. Many kinds of rocks are composed of minerals
   a) Granite; mica, feldspar and quartz
2. Monomineralic; rocks that are composed of only one mineral.
   a) Marble–Calcite
3. Polymineralic; rocks that are composed of two or more minerals
   a) Granite
4. There are almost 4,700 different minerals
   ➢ Silicates make up 90% of the crust.
COMMON ROCK FORMING MINERALS

- Quartz: 12%
- Pyroxene: 11%
- Potassium Feldspar: 12%
- Plagioclase Feldspar: 39%
- Hornblende/Amphibole: 5%
- Biotite Mica: 5%
- Clays: 5%
- Olivine: 3%
- Other: 8%
II. Rocks are classified based on their method of formation/origin.

A. 3 Rock Groups
   1. Sedimentary
   2. Igneous
   3. Metamorphic
SEDIMENTARY ROCKS

B. Rocks that usually form in horizontal layers; from the accumulation of sediment, organic matter, or chemical precipitates

1. Form underwater in lakes, seas or oceans
2. Mostly composed of quartz, feldspar and clay.

Layers of sediment deposit and accumulate

Pressure/weight squeezes lower layers

Sediment is compacted and cemented into rock
a) **Clastic**: form from mineral particles and sediment that are **compacted** and **cemented** together.

1) Compaction: **pressed** by weight of overlying rock
2) Cementation: **glued** by natural cements in water
   - Calcite
## Clastic Rocks

<table>
<thead>
<tr>
<th>Texture</th>
<th>Grain Size</th>
<th>Composition</th>
<th>Comments</th>
<th>Rock Name</th>
<th>Map Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clastic</td>
<td>Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay</td>
<td>Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals</td>
<td>Rounded fragments</td>
<td>Conglomerate</td>
<td><img src="image" alt="Conglomerate" /></td>
</tr>
<tr>
<td>Clastic</td>
<td>Sand (0.2 to 0.006 cm)</td>
<td></td>
<td>Angular fragments</td>
<td>Breccia</td>
<td><img src="image" alt="Breccia" /></td>
</tr>
<tr>
<td>Clastic</td>
<td>Silt (0.006 to 0.0004 cm)</td>
<td></td>
<td>Fine to coarse</td>
<td>Sandstone</td>
<td><img src="image" alt="Sandstone" /></td>
</tr>
<tr>
<td>Clastic</td>
<td>Clay (less than 0.0004 cm)</td>
<td></td>
<td>Very fine grain</td>
<td>Siltstone</td>
<td><img src="image" alt="Siltstone" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Compact; may split easily</td>
<td>Shale</td>
<td><img src="image" alt="Shale" /></td>
</tr>
</tbody>
</table>
b) **Chemical**: form from minerals dissolved in water; which settle-out/**precipitate**.

1) Dissolved **minerals** are **left behind** when water evaporates.

<table>
<thead>
<tr>
<th>TEXTURE</th>
<th>GRAIN SIZE</th>
<th>COMPOSITION</th>
<th>COMMENTS</th>
<th>ROCK NAME</th>
<th>MAP SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalline</td>
<td>Varied</td>
<td>Halite</td>
<td>Crystals from chemical precipitates and evaporites</td>
<td>Rock Salt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Varied</td>
<td>Gypsum</td>
<td></td>
<td>Rock Gypsum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Varied</td>
<td>Dolomite</td>
<td></td>
<td>Dolostone</td>
<td></td>
</tr>
</tbody>
</table>
## TYPES OF SEDIMENTARY ROCK

c) **Organic**: form from the accumulation of **plant/animal matter** that undergoes a transformation into rock.

<table>
<thead>
<tr>
<th>Bioclastic</th>
<th>Microscopic to coarse</th>
<th>Calcite</th>
<th>Cemented shell fragments or precipitates of biologic origin</th>
<th>Limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varied</td>
<td>Carbon</td>
<td>From plant remains</td>
<td>Coal</td>
<td></td>
</tr>
</tbody>
</table>
FORMATION OF COAL

Time

Pressure

Heat

Peat

Lignite

Coal

Burial pressure, heat, and time

Peat

Lignite

Bituminous

Sub-bituminous

Anthracite
SEDIMENTARY CHARACTERISTICS

a) They are composed of rock, mineral or organic particles.
b) Some have a range of particle sizes.
   1) Pebbles, cobbles, boulders, in a sand, silt or clay
      a) Conglomerate: rounded fragments
      b) Breccia: angular fragments.
c) Some have a **uniform** sediment size; due to sorting during deposition

1) **Sandstone:**
   - 0.2 - 0.006 cm

2) **Siltstone:**
   - 0.006 - 0.0004 cm

3) **Slate:**
   - less than 0.0004 cm
SEDIMENTARY CHARACTERISTICS

d) Some rocks are organic and may contain **fossils**.

1) Coquina

e) Usually form in **horizontal** layers called **strata or beds**
C. Form from the cooling and crystallization/solidification of molten lava or magma.

1. When molten lava or magma cools and solidifies, the crystals of different minerals form a rock.

2. The rock contains a crystalline structure of intergrown crystals of different sizes, shapes, and composition.
TYPES OF IGNEOUS ROCKS

a) Extrusive/Volcanic: Forms from the fast cooling of lava on or near Earth’s surface.

1) Rapid cooling does NOT allow time for crystals to grow.

2) Rocks have small to no crystals; smooth/fine texture.
## Extrusive/Volcanic Igneous Rocks

<table>
<thead>
<tr>
<th>Extrusive (Volcanic)</th>
<th>Obsidian (usually appears black)</th>
<th>Basaltic glass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pumice</td>
<td>Scoria</td>
</tr>
<tr>
<td>Vesicular rhyolite</td>
<td>Vesicular andesite</td>
<td>Vesicular basalt</td>
</tr>
<tr>
<td>Rhyolite</td>
<td>Andesite</td>
<td>Basalt</td>
</tr>
</tbody>
</table>
TYPES OF IGNEOUS ROCKS

b) Intrusive/Plutonic: Form from the slow cooling of magma within the Earth

1) Slow cooling allows time for large crystals to grow

2) Rocks have large crystals; coarse/rough texture
INTRUSIVE/PLUTONIC IGNEOUS ROCKS

<table>
<thead>
<tr>
<th>Intrusive (Plutonic)</th>
<th>Granite</th>
<th>Diorite</th>
<th>Diabase</th>
<th>Gabbro</th>
<th>Peridotite</th>
<th>Dunite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pegmatite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>Rate of cooling</td>
<td>Grain Size</td>
<td>Texture</td>
<td>Example</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>---------</td>
<td>------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extrusive (Volcanic)</td>
<td>Very Fast</td>
<td>Non-crystalline</td>
<td>Glassy</td>
<td>Obsidian Pumice</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td>Less than 1mm</td>
<td>Fine</td>
<td>Basalt Rhyolite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrusive (Plutonic)</td>
<td>Slow</td>
<td>1mm or larger</td>
<td>Coarse</td>
<td>Granite Diorite</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1) Location in Earth’s crust affects the cooling rate and crystal size.
MINERAL COMPOSITION
(RELATIVE BY VOLUME)

PG 6
FELSIC VS MAFIC COMPOSITION

1) Felsic – Pumice, Rhyolite, Granite
   a) Composition – rich in Silicon (Si) and Aluminum (Al)
   b) Density – lower densities; Pumice = 0.64g/cm³
   c) Color – lighter; clear, white, pink, grey, black

2) Mafic – Scoria, Basalt, Gabbro
   a) Composition – rich in Iron (Fe) and Magnesium (Mg)
   b) Density – higher densities; Scoria = 2.55 g/cm³
   c) Color – darker; white, gray, back, and green
COMPARE THE MAIN IDEAS

FLESIC

HOW ALIKE?

MAFIC

HOW DIFFERENT
WITH REGARD TO

PATTERNS OF SIGNIFICANCE:
METAMORPHIC ROCKS

D. Rocks that form from **pre-existing** rocks (sedimentary, igneous, **metamorphic**); that have been **changed**.

1. **Molecules** can rearrange and form new rocks due to **contact** with extreme heat (magma), or extreme **pressure** (orogeny)

2. Often found in **mountainous** regions where the deeper **bedrock** is exposed due to **weathering** and **erosion**
METAMORPHISM

a) **Conditions** that cause rocks to undergo metamorphism

1) Heat
2) Pressure
3) Chemical Activity

b) **Contact Metamorphism**

1) Rocks around a magma/lava can be metamorphosed through direct contact with the magma/lava

c) **Regional Metamorphism**

1) Rocks buried deep within the crust can re-crystallize due to extreme pressure during mountain building events
4. Environments within the crust have **high** temperatures and **high** pressure; causing rocks to **change** by recrystallization.

1) No true melting; called **partial melt** (plastic)
2) **Increased Density**
3) **Chemical Change/New Minerals**
4) **Foliated/Non-foliated**

- New mineral crystals can grow from the sediment in sedimentary rock, and from the “old” crystals in an igneous rock.
### TYPES OF METAMORPHIC ROCK

**TEXTURE**

**a) Foliated:** Rock has mineral crystals arranged in **layers** or parallel **bands**.
- Mineral Alignment: **Schist**, Slate, & Banding: **Gneiss**

---

#### Scheme for Metamorphic Rock Identification

<table>
<thead>
<tr>
<th>Texture</th>
<th>Grain Size</th>
<th>Composition</th>
<th>Type of Metamorphism</th>
<th>Comments</th>
<th>Rock Name</th>
<th>Map Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foliated</td>
<td>Fine</td>
<td>Microcline</td>
<td>Low-grade metamorphism of shale</td>
<td>Slate</td>
<td>Slate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fine to medium</td>
<td>Quartz</td>
<td>Foliation surfaces shiny from microscopic mica crystals</td>
<td>Phyllite</td>
<td>Phyllite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium to coarse</td>
<td>Amphibole</td>
<td>Platy mica crystals visible from metamorphism of clay or feldspars</td>
<td>Schist</td>
<td>Schist</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pyroxene</td>
<td>High-grade metamorphism; mineral types segregated into bands</td>
<td>Gneiss</td>
<td>Gneiss</td>
<td></td>
</tr>
</tbody>
</table>

---

58
1) Mineral **Alignment**: Minerals join; but do **not** form **visible** layers.
   a) Creates a shine or **veneer** on the rock
   b) **Slate**, Phyllite and Schist

2) **Banding**: Mineral **crystals** join and **arrange** in **layers**; **Gneiss**
   a) **Increase** in **heat** and **pressure** usually produces **thicker** bands of alternating **crystals**
   b) Distorted **Structure**: The **folding** of the mineral **bands** due to extreme **pressure** exerted on the rock.
b) **Non-Foliated/Unfoliated**: Rock does not have mineral crystals arranged in layers; do not break in layers/sheets

1) **Marble**, Quartzite, Anthracite Coal

<table>
<thead>
<tr>
<th>NONFOLIATED</th>
<th>Fine</th>
<th>Regional</th>
<th>Metamorphism of bituminous coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>Carbon</td>
<td>Contact (heat)</td>
<td>Various rocks changed by heat from nearby magma/lava</td>
</tr>
<tr>
<td>Fine to coarse</td>
<td>Various minerals</td>
<td>Regional or contact</td>
<td>Metamorphism of quartz sandstone</td>
</tr>
<tr>
<td>Coarse</td>
<td>Various minerals</td>
<td></td>
<td>Metamorphism of limestone or dolostone</td>
</tr>
</tbody>
</table>

- **Anthracite coal**
- **Hornfels**
- **Quartzite**
- **Marble**
- **Metaconglomerate**
### Metamorphic Rocks

<table>
<thead>
<tr>
<th>Texture</th>
<th>Metamorphic Rock</th>
<th>Original Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foliated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slate</td>
<td></td>
<td>Shale</td>
</tr>
<tr>
<td>Schist</td>
<td></td>
<td>Slate</td>
</tr>
<tr>
<td>Gneiss</td>
<td></td>
<td>Granite</td>
</tr>
<tr>
<td>Un-foliated</td>
<td>Marble</td>
<td>Limestone</td>
</tr>
<tr>
<td></td>
<td>Quartzite</td>
<td>Sandstone</td>
</tr>
<tr>
<td></td>
<td>Anthracite Coal</td>
<td>Bituminous Coal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sedimentary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sedimentary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sedimentary</td>
</tr>
</tbody>
</table>
MAIN IDEA RELATIONSHIPS

Cause

Metamorphosis

Effect

Cause

Effect

Cause
E. The Rock Cycle: pg 6 of ESRT’s

1. Any rock can become any other rock as shown by the processes in the rock cycle.
FAMOUS ROCKS

- Grand Canyon; layers of sedimentary rocks
- Mount Rushmore; Granite
- White House; Sandstone
- Pyramids; Limestone
- Great Wall of China; stone; brick, etc...
- Stonehenge
ROCK RELATIONSHIPS
Rocks

- Sedimentary
  - Clastic Sediment
    - Conglomerate
    - Sandstone
    - Siltstone
    - Shale
  - Organic Bioclastic
  - Crystalline Chemical
  - Limestone
    - Rock Salt
    - Rock Gypsum

- Igneous
  - Intrusive Plutonic
    - Granite
    - Gabbro
    - Diorite
  - Extrusive Volcanic
    - Pumice
    - Obsidian
    - Basalt
    - Rhyolite

- Metamorphic
  - Foliated
    - Slate
    - Schist
    - Gneiss
  - Unfoliated
    - Marble
    - Quartzite
    - Anthracite Coal
UNIT CONNECTIONS

Rocks and Minerals

Igneous Rocks
- Obsidian
- Granite
- Basalt
- Pumice
- Gabbro

Sedimentary Rocks
- Sandstone
- Breccia
- Limestone
- Conglomerate
- Shale

Metamorphic Rocks
- Schist
- Slate
- Marble
- Quartzite
- Gneiss

Minerals
- Quartz
- Talc
- Magnetite
- Halite
- Feldspar
- Gold
- Diamond
- Silver
- Copper
- Mica

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Dynamic Crust

<table>
<thead>
<tr>
<th><strong>Strategy:</strong></th>
<th>Activating Cognitive Schema</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Descriptive, pictorial</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>As students explore what they know about a new topic and how they may identify with it, they are required to activate the schema necessary to continue learning about the topic at hand. This strategy creates a pathway for deeper understanding and learning, as ideas are scaffolded throughout the notes. By activating prior knowledge and communicating that knowledge in several different ways students learn to reflect on their understanding of the topic before it is introduced.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
<td>Page 1, Slide 2</td>
</tr>
<tr>
<td><strong>Reference:</strong></td>
<td>Thinking Questions; Kagan (1999)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Strategy:</strong></th>
<th>Summative Cognitive Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Descriptive, textual, pictorial</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>Throughout the note-packets students are asked to copy and create several drawings. Summative descriptive strategies provide students with the opportunity to combine the main ideas and drawings from within the lecture; into a cohesive statement of understanding. Through this process students and teachers can monitor how students make connections between new ideas and previous knowledge. These strategies provide insight into student comprehension and perception of segmented and holistic scientific systems and processes.</td>
</tr>
</tbody>
</table>
| **Location(s):** | Page 5, Slide 14  
Page 21, Slide 70, 71 |
| **Reference:** | Thinking Questions; Kagan (1999) |
**Strategy:** Summative Cognitive Reflection  

**Modes of Communication:** Depictive, symbolic

**Rational:** Units within the Earth Science curriculum, introduce students to major ideas about the physical world around us with tremendous amounts of detail. Students must understand these details to properly communicate the broader ideas within a unit. Summative depictive strategies provide students with the opportunity to work through and review the textual information within their notes. As they review these new ideas and relationships students illustrate their thinking processes through graphic organizers or mind mapping tasks. These strategies allow teachers and students to visualize connections that students are making with new information and promote discussion and assessment of internal comprehension.

**Location(s):**  
Page 11, Slide 42  
Page 22, Slide 72

**Reference:**  
Thinking Questions; Kagan (1999)  

---

**Strategy:** Visual Representation

**Modes of Communication:** Descriptive, pictorial, iconic

**Rational:** Visual representations are meant to provide students with an illustration of an idea or word without demanding more from their working memory. Visual-descriptive strategies allow students to illustrate properties of an idea, rather than focus on the textual information. Student perceptions of the concept and its properties are prominent in this strategy. Teachers should allow students opportunities to revise or add to images created during note taking.

**Location(s):**  
Page 2, Slide 3&4  
Page 6, Slide 17  
Page 8, Slide 20
**Strategy:** Visual Interpretation

**Modes of Communication:** Depictive, pictorial, symbolic

**Rational:** Focusing on the textual information provided within the notes students create mental and physical images. The visual-depictive strategy will aid in the creation of mental models as note taking occurs. In each instance the student is asked to interpret the text and create an illustration that depicts their understanding. This creates an internal connection between the student and the concept, as well as supporting informal assessment techniques.

**Location(s):**
Page 10, Slide 26
Page 10&11, Slide 31, 32, 33, 34, 35, 36, 37, 38

**Strategy:** Graphic Interpretation

**Modes of Communication:** Descriptive, pictorial

**Rational:** Throughout the Earth Science curriculum and within the NYS Regents exams students are expected to interpret information from and add information to a multitude of diagrams. Within the graphic-descriptive strategy students are asked to analyze diagrams for information and add or pull information from the diagrams based on information provided within the unit. The use of this strategy affords teachers with the opportunity to nurture the use of diagrams, and provides students with a basis for the utilization of diagrams in science.

**Location(s):**
Page 13, Slide 44
Page 14, Slide 48
Page 15&16, Slide 50, 51, 52, 53
Dynamic Crust

I. Evidence of Crustal Movement

A. Crustal Changes –

1. Non-horizontal Strata:

   a) ____________________________ strata are normally deposited in
      ____________________________ layers.

   (1) Any change from horizontal tells us there was ____________
       movement.
B. Fossil Evidence –

1. ___________ fossils found at high ___________ suggests crustal ___________.

2. Shallow water marine fossils found at great ocean depth suggests crustal ___________ / ___________.

Normal Environment
C. Theory of Continental Drift – Alfred

1. 200 ______, all the continents existed as one large land mass called ________

![Diagram of Continental Drift](image-url)
2. Evidence Supporting Continental Drift:

a) ___________________________ -like Fit - the __________________________ of the continents

seemed to have ___________________________ like a large jigsaw puzzle.

(1) __________________________ coast of South America fits well with the __________________________ coast of Africa.

b) __________________________ Clues - certain ancient life forms are __________________________ as

fossils on widely __________________________

(1) __________________________ - reptile, __________________________ - fern

![Diagram of continents fitting together](image)

![Fossil images](image)

c) Rock Clues - Mountain __________________________ and rock patterns

(1) The __________________________ mountains on the __________________________ coast

of the __________________________, are geologically __________________________ to the Caledonian

Mtns. in Scotland, __________________________ and __________________________

(2) __________________________, __________________________ and mineral __________________________

are __________________________ on the __________________________ coast of __________________________

and the Western coast of __________________________.
d) ________________ clues.

(1) ________________ - forms from the burial of plants in __________
_____________ environments.
   (a) Currently found in the colder climates of N. America and
______________.

(2) ________________ - contains corals from warm
______________.
   (a) Currently found in _____________ latitudes such as ____________.

(3) Glaciers -
   (a) Ancient rocks of the same age near the ________________ in
S. America, S. Africa and other southern continents show
 evidence of ____________________________.

All the continents once existed as one large land mass called Pangea

<p>| | | | |</p>
<table>
<thead>
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</tbody>
</table>

What general rule can you make from this evidence?
D. Theory of Seafloor Spreading – Harry __________

1. The idea that the seafloor itself moves, and carries the continents with it, as it expands from a central point.

2. Topography of the Ocean Floor:

3. Evidence of Seafloor Spreading:
   a) ________ Evidence – as the ________________ from an ocean ridge ________________, the _______ of the rock
       (1) As the distance from a ___________ increases, the age of the rock will ________________.
b) Paleo-______Evidence – ancient magnetic clues in the
________-bearing basalt on the ocean floor supports the theory of seafloor
spreading.

Polarity

Normal/Positi  Reverse/Negativ

Positive magnetic anomaly  Negative magnetic anomaly

A. Period of normal magnetism
B. Period of reverse magnetism
C. Period of normal magnetism

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II. Plate Tectonics – thin, lithospheric ______________ are in motion and “_________” or ride on the ________________, the plastic-like layer beneath the lithosphere.

A. Earth’s Layers and Composition

1. The Lithosphere is composed of the crust and ______________ mantle
2. The Asthenosphere is a ______________ layer of the upper mantle.
3. The Earth is layered according to ______________ values.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crust</td>
<td>5-____ km</td>
<td></td>
</tr>
<tr>
<td>Mantle</td>
<td>_____ km</td>
<td></td>
</tr>
<tr>
<td>Outer Core</td>
<td>_____ km</td>
<td></td>
</tr>
<tr>
<td>Inner Core</td>
<td>_____ km</td>
<td></td>
</tr>
</tbody>
</table>

Cross Section of Earth: pg _______ ESRT’s
B. Driving Force Causing Plate Tectonics

1. ___________ currents:
   a) Hot, _________ dense, magma from deep within the mantle ___________
   b) As the magma rises it cools, becomes _________ dense and __________

2. The convective __________ of magma in the mantle __________ /
   lithospheric ______ across Earth’s surface.

3. Major Plates and Plate Boundaries: pg _____ ESRT’s

   a) The Theory of Plate Tectonics states that Earth’s lithosphere is divided into
      sections called lithospheric plates.

   b) __________________________ and interact with each other at plate
      __________________________.
(1) Direction of Relative Plate Motion:

(a) ____________ : ____________ from each other

(b) ____________ : ____________ each other

(c) ____________ : _______ passed each other.

(2) Divergent Plate Boundaries – This is where two plates are being

__________________________ . (splitting of Pangaea)

(a) ____________ : Oceanic crust, _________________

(b) ____________ : Continental crust, _________________

(3) Convergent Plate Boundaries – where two plates come together

and _________________.

(a) Plate ________________ determines the ________________

of the collision.

(b) ________________ : ________________

(i) More dense ____________ crust will ____________,

   or dive under, less dense ________________ crust

   and sinks into the _________________.

(ii) Sometimes rising through the continental crust as it

    becomes _________________.

(iii) The ________________ plate, oceanic, subducts

     under the South ________________ Plate, continental.
(c) 

(i) Continental crust collisions will produce mountain
        
        _______ events.
(ii) Indian plate colliding with the Eurasian plate; forming
        the ________________ mtns.

(d) 

(i) Oceanic crust collisions produce ________________
        and ________________.
(ii) Trenches and island arcs formed ___________ and
        the ________________ islands of Alaska.

(4) Transform Plate Boundaries - where two plates move ___________

        each other in ________________ directions.

(a) The Pacific plate and North American plate move passed each
        other; creating the ________________, in California.
C. Earthquakes -

1. Seismology: The branch of science that studies Earthquakes

2. Cause: __________ movement of Earth’s crust at plate _________
or faults.

   a) Types of Faults:

   (1) ___________ fault – _______________ boundaries

   (a) Hanging wall moves down

   (b) Usually produces __________, __________ quakes.

   (2) Reverse fault – _______________ boundaries

   (a) Hanging wall block moves _____________.

   (b) Produces ___________, ___________ quakes

   (3) ___________ fault – _______________ boundaries

   (a) Blocks move side to side

   (b) Produces ___________, ___________ quakes
3. Earthquake Terms –

   a) Focus: The _______ beneath the Earth’s surface where _______
      movement releases seismic waves/___________.

   b) _________: point on Earth’s surface ____________
      ______ the focus.

   ![Image showing depth and fault lines]

   Key
   - Shallow = within 75 km of Earth’s surface
   - Intermediate = 75 to 300 km below Earth’s surface
   - Deep = 300 to 700 km below Earth’s surface

   ![Diagram of seismic waves]

   c) Seismic waves: energy released from the focus in the form of waves.

      (1) P-waves - ________ waves are _______ and travel ________ and arrive at monitoring stations before any other earthquake waves.

         (a) P-waves can travel through solids and liquids.

      (2) S-waves - ________ waves are _______ and travel at ________, and arrive at monitoring stations after primary waves.

         (a) S-waves can only travel through solids.
(3) By analyzing wave patterns scientists have been able to infer the interior of Earth.

d) Seismometer: instrument used to measure and record earthquake waves at seismic stations.

e) Seismogram: the paper report of wave data recorded by a seismograph.
4. Locating the Epicenter of an Earthquake

a) Record arrival times of the $S$ and $P$ waves, from at least ______ different seismic stations.

![Graph showing P and S waves arrival times]

2. Chicago, Illinois

![Graph showing P and S waves arrival times]

3. Seattle, Washington

![Graph showing P and S waves arrival times]

<table>
<thead>
<tr>
<th>Seismograph Station</th>
<th>Arrival Time</th>
<th>Difference in Arrival Time</th>
<th>Distance to Epicenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houston</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicago</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seattle</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Use pg ______ of ESRT's to find the distance each wave traveled.
b) Use a drawing compass to make accurate circles around the seismic station location.

The United States

Seattle

Chicago

Houston

c) Where the three circles meet is the epicenter. Mark this with an X.

5. Measuring an Earthquake

Understanding the Richter Scale

<table>
<thead>
<tr>
<th>Magnitude (on a scale of 0-9)</th>
<th>Richter Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Minor Earthquake</td>
</tr>
<tr>
<td>2</td>
<td>Earthquake felt only by a few people</td>
</tr>
<tr>
<td>3-4</td>
<td>Minor Earthquake</td>
</tr>
<tr>
<td>5-6</td>
<td>Moderate Earthquake</td>
</tr>
<tr>
<td>7-8</td>
<td>Severe Earthquake</td>
</tr>
<tr>
<td>9</td>
<td>Great Earthquake</td>
</tr>
</tbody>
</table>

Scale: used to express the strength or magnitude by an earthquake.

(1) The scale increases 10-fold each level

(a) A 3 is _______ times greater than a 2, and 100 times greater than a _______.

b) __________________ scale: measures the _______________ damage caused by the quake on a scale of ________________.
6. ___________: gigantic sea-wave
   a) Speed: ____________
   b) Height: ____________

D. Volcanoes:

1. Causes of Volcanic Activity
   a) ______________: Oceanic____________ crust
      (1) ___________ and rifts contain volcanoes and hydrothermal ____________.

   b) ______________: Oceanic - Oceanic crust
      (1) ___________ bearing minerals, brought down with the subducting plate causes the rock to ____________.
      (2) This magma____________ through overlying ____________ and creates deep sea volcanoes.
      (a) These volcanoes ____________ over time and can sometimes form ____________.
c) **Converging:**_________________________ - ____________________________ crust

(1) As the ____________________________ plate is pulled deeper into the upper ____________________, the plate begins to melt and rises as magma intrusions.

(a) Builds _________________________ on the surface of the overlying continental crust.

2. The ________________________________ - 
3. ___________ : results from the ___________ movement of a tectonic plate over a “fixed” point in the mantle that is ___________ than the mantle around it.

   a) Causes:

   (1) A narrow ___________ of hot ___________ convecting up from Earth’s ___________ - ___________ boundary.

       (a) Called a mantle ___________

   (2) Upper- mantle ___________

   b) Ex: _________________________

   ![Diagram: Main Features of a Volcano]

4. Types of Volcanoes

   a) ___________ Cone – non-explosive eruptions

       (1) Built from repeated ________________________________.

       (2) ___________ sloping sides.

   ![Diagram: Volcano Structure]
b) __________________ cone - __________________ eruptions.

(1) Built from __________________ (volcanic ______ & ______)

(2) __________________ sloping sides.

______________________________ cone – repeated __________________ & __________________ eruptions.

(1) Built from __________________ layers of lava and __________

(2) __________________ sloping sides

5. Volcanic/__________ features – Igneous intrusions
DYNAMIC CRUST

Crustal Movement
Inside the Earth

- Draw a cross-sectional view of the Earth
  - What are the different parts of the Earth?
    - How are they similar or different?
  - Explain or illustrate the occurrence of earthquakes and volcanoes.
Evidence of Crustal Changes

a) Sedimentary strata are normally deposited in horizontal layers.
   1) Any change from horizontal indicates crustal movement.
      a) Tilting, Faulting, Folding
      □ No motion

□ Normal undisturbed layers
Crustal Changes

- **Tilted Strata:**
- **Faulted Strata:**
- **Folded Strata:**
1) Marine fossils found at high elevations suggest crustal uplift.
2) Shallow water marine fossils found at great ocean depths suggest crustal subsidence/sinking.
Theory of Continental Drift

C. Alfred Wegener proposed the theory of Continental Drift in the early 1900’s.

1) 200 mya, all the continents existed as one large land mass which he called Pangea.

- Pangea - A supercontinent that included all the landmasses of the earth before the Triassic Period. When continental drift began, Pangaea broke up into Laurasia and Gondwanaland.
a) Puzzle like-fit

a) The coastlines of the continents seemed to have fit together like a large jig-saw puzzle.

1) The East coast of South America fits well with the West coast of Africa.
b) Fossil Clues

b) Certain ancient life forms are **found** as fossils on widely separated continents.

1) **Mesosaurus** - Small freshwater reptile; found in S.America and Africa.

1) **Glossopteris** - Ancient seed ferns; found in Africa, India, Australia, Antarctica, S. America.
c) Rock Clues

Mountain Chains

1) The Appalachian Mountains on the East coast of U.S. are geologically similar to the Caledonian Mountains in Scotland, Europe and Greenland.

2) Structure, age and mineral content of rocks are similar on the coasts of Eastern S. America and Western Africa.
d) Climate Clues

1) **Coal**, which forms from the burial of plants in **warm swampy** environments, is currently found in the colder climates of N. America and **Antarctica**.

2) **Coral Limestone**, contains coral from **warm seas**.
   a) can currently be found in places of **higher latitudes** such as **NYS**.
3) Glaciers

a) Ancient rocks of the same age near the **equator** in S. America, S. Africa and other southern continents show evidence of **glaciation**

- Glaciers once moved into and then out of these areas
Climate Clues
Continental Drift Over Time

- **Permian**: 225 million years ago
- **Triassic**: 200 million years ago
- **Jurassic**: 135 million years ago
- **Cretaceous**: 65 million years ago

Image by USC2.org
**Constructing Support**

<table>
<thead>
<tr>
<th>All the continents once existed as one large land mass called Pangea</th>
</tr>
</thead>
</table>

What general rule can you make from this evidence?
What is Missing?

- This theory was almost unanimously denied as probable within the global scientific community.
  - There was no mechanisms to explain how this had happened.
- Wegener merely proposed that it had.
  - This theory and others were delayed until a driving force was added to the theory
Theory of Seafloor Spreading

D. Proposed by Harry Hess
Evidence of Sea Floor Spreading

a) **Age Evidence:** As the distance from an ocean ridge **increases** the age of the rock **increases**.

1) As the distance from a **trench** increases the age of the rock will **decrease**.
Evidence of Sea Floor Spreading

b) **Paleo-Magnetic** Evidence: Ancient magnetic clues in the **iron-bearing basalt** \((\text{igneous})\) rock of the ocean floor supports the theory of seafloor spreading.
Plate Tectonics

II. The theory of plate tectonics states that, thin, lithospheric \textit{plates} are in motion and "\textit{float}" or ride on the \textit{asthenosphere}, a plastic-like layer beneath the lithosphere.
Earth’s Surface

1) Lithosphere = Crust + Rigid Mantle
2) Asthenosphere: plastic-like layer of the upper mantle
3) **Density Values:**
- Crust: 2.7 - 3.0 g/cm³
- Mantle: 3.4 – 5.6 g/cm³
- Outer core: 9.9 – 12.2 g/cm³
- Inner Core: 12.8-13.1 g/cm³

- Thickness:
  - Continental Crust: 32 - 100 km
  - Ocean Crust: 5 – 8 km
Cross-Section of Earth; pg 10
The driving force beneath the plates

1) Convection Currents:
   a) Hot less dense molten rock from deep within Earth’s mantle rises.
   b) When this magma cools near the surface, it becomes more dense and sinks.
2) This convective flow of magma in the mantle pushes/pulls lithospheric plates across the surface of Earth.

- Ridge Push
- Slab Pull
3) Major plates and plate boundaries

pg 5 ESRT's

a) The Theory of plate tectonics states that Earth’s lithosphere is divided into sections called lithospheric plates.
b) **Plates meet** and interact with each other at **plate boundaries**

1) Direction of relative plate motion:
   a) **Divergent:** away from each other
   b) **Convergent:** towards each other
   c) **Transform:** slide passed each other
Ocean Ridges and Trenches
Divergent Plate Boundaries

2) This is where two plates are being **pulled apart**.
   - Splitting of Pangea

   a) **Ridges**: Oceanic crust
   b) **Rifts**: Continental crust
Divergent Crust Examples

Oceanic Crust: Oceanic Ridge

Continental Crust: Kenya; Rift Valley
Convergent Plate Boundaries

3) This is where two plates come together and "collide."

a) Plate composition determines the outcome of the collision.

- Oceanic-Continental
- Continental-Continental
- Oceanic-Oceanic
Convergent Plate Boundaries

b) **Oceanic-Continental:**
   
   i. More dense oceanic crust will *subduct*, or dive under, the less dense continental crust and sink into the *mantle*.
   
   ii. Sometimes rising again as it becomes *heated*.
   
   iii. Pacific Plate (oceanic) subducts *under* the South American Plate (continental)
Subduction & Volcanic Mtns.
Convergent Plate Boundaries

c) **Continental-Continental:**

i. Continental crust collisions will produce mountain **building** events; Orogenesis

ii. India colliding with Asia; forming the **Himalaya** Mountains.
Continental Mountain Chains

[Diagram showing continental crust, lithosphere, asthenosphere, and high plateau]
Convergent Plate Boundaries

d) **Oceanic-Oceanic**: Slab-Pull

i. Oceanic crust collisions produce *trenches* and *island arcs*

ii. Trenches and island arcs formed **Japan** and **Aleutian Islands, Alaska**
Trenches & Island Arc

Oceanic crust

Island arc

Continental crust

Lithosphere

Asthenosphere

Oceanic-oceanic convergence
Transform Plate Boundaries

4) This is where two plates move **passed** each other in opposite directions

a) San Andreas Fault
Left-lateral movement
Earthquakes

1. Seismology: the branch of science that studies earthquakes

2. Causes: Sudden movement of Earth’s crust at plate boundaries or faults
Earthquake - Faults

1) **Normal Faults - Divergent Boundaries**
   b) usually produce *minor, shallow* quakes.

2) **Reverse Faults - Convergent Boundaries**
   a) Hanging wall block moves *upward*.
   b) produce *strong, deep* quakes
   - Ocean-Continental
   - Ocean-Ocean
   - Continental-Continental
Earthquake – Faults

3) **Strike-Slip Faults/Transform** Boundaries
   b) produce moderate shallow quakes.
Connecting Ideas

[Blank Fishbone Diagram]

Detail

Cause

Effect

[Diagram showing a fishbone structure with labeled branches for Cause, Detail, and Effect]
Earthquakes

a) Focus: point beneath Earth’s surface where fault movement releases seismic waves/energy.

b) Epicenter: point on Earth’s surface directly above the focus.
Earthquakes and Surface Movement

Seismic waves: energy released from the focus in the form of waves.

**Key**

- **Shallow** = within 75 km of Earth’s surface
- **Intermediate** = 75 to 300 km below Earth’s surface
- **Deep** = 300 to 700 km below Earth’s surface
Earthquake Waves

1) P-waves - primary waves are compressional waves
   - travel at 6 mph
   - first wave to arrive at monitoring stations
   a) P-waves can travel through solids and liquids.

2) S-waves - Secondary waves are shear waves,
   - travel at 4 mph
   - second wave to arrive at monitoring stations
   a) S-waves can only travel through solids.
# Earthquake Waves

<table>
<thead>
<tr>
<th>Types of Waves</th>
<th>Proper Name</th>
<th>Travel Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-Waves</td>
<td>Primary/ Compressional</td>
<td>6 mps</td>
</tr>
<tr>
<td>S-Waves</td>
<td>Secondary/ Shear</td>
<td>4 mps</td>
</tr>
</tbody>
</table>
3) Analysis of seismic waves has led scientists to infer the interior **structure** of Earth.
P & S wave paths
d) **Seismograph**: measures and records earthquake waves

e) **Seismogram**: the wave data recorded by the seismograph
a) Record arrival times of the S and P waves, from at least 3 different seismic stations.
## Seismic Data

<table>
<thead>
<tr>
<th>Seismograph Station</th>
<th>Arrival Time</th>
<th>Difference in Arrival Time</th>
<th>Distance to Epicenter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P-wave</td>
<td>S-wave</td>
<td></td>
</tr>
<tr>
<td>Houston</td>
<td>00:13:00</td>
<td>00:16:00</td>
<td></td>
</tr>
<tr>
<td>Chicago</td>
<td>00:15:00</td>
<td>00:19:00</td>
<td></td>
</tr>
<tr>
<td>Seattle</td>
<td>00:12:00</td>
<td>00:14:40</td>
<td></td>
</tr>
</tbody>
</table>
Earthquake S-Wave and P-Wave Travel Time Chart; pg 11
How to Locate an Epicenter
Measuring an Earthquake

a) Richter Scale - used to express strength or energy released; on a scale from 1 to 10.

- This scale is ten-fold; each number is 10 times more than the next.

1) 3 is 10 times more than 2 and 100 times more than 1.

<table>
<thead>
<tr>
<th>Frequency of Occurrence of Earthquakes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Descriptor</strong></td>
</tr>
<tr>
<td>Great</td>
</tr>
<tr>
<td>Major</td>
</tr>
<tr>
<td>Strong</td>
</tr>
<tr>
<td>Moderate</td>
</tr>
<tr>
<td>Light</td>
</tr>
<tr>
<td>Minor</td>
</tr>
<tr>
<td>Very Minor</td>
</tr>
</tbody>
</table>

1 Based on observations since 1900.
2 Based on observations since 1990.
Richter & Mercalli

b) **Mercalli Scale** - a scale used to show the physical damage caused by an earthquake by assigning a number from I\(^{(1)}\) to XII\(^{(12)}\).

![Modified Mercalli Scale]

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Observed Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Fell by only a few people under very special circumstances</td>
</tr>
<tr>
<td>II</td>
<td>Fell by only a few people at rest, especially on the upper floors of buildings</td>
</tr>
<tr>
<td>III</td>
<td>Fell noticeably indoors, especially on upper floors of buildings</td>
</tr>
<tr>
<td>IV</td>
<td>Fell indoors by many people, outdoors by a few; some awakened</td>
</tr>
<tr>
<td>V</td>
<td>Fell by nearly everyone; many awakened; dishes and windows break; plaster cracks</td>
</tr>
<tr>
<td>VI</td>
<td>Fell by everyone; many frightened and run outdoors; heavy furniture moves</td>
</tr>
<tr>
<td>VII</td>
<td>Everyone runs outdoors; slight to moderate damage in ordinary structures</td>
</tr>
<tr>
<td>VIII</td>
<td>Considerable damage in ordinary structures; chimneys and monuments fall</td>
</tr>
<tr>
<td>IX</td>
<td>Considerable damage in all structures; ground cracks; underground pipes break</td>
</tr>
<tr>
<td>X</td>
<td>Most structures destroyed; nails bend; landslides occur; water splashes over banks</td>
</tr>
<tr>
<td>XI</td>
<td>Few structures left standing; bridges destroyed; broad fissures in the ground; underground pipes break</td>
</tr>
<tr>
<td>XII</td>
<td>Damage total; waves seen on ground surfaces; objects thrown in air</td>
</tr>
</tbody>
</table>
**Tsunami**

6. Gigantic sea waves  
   a) Speed: 400 – 500 mph  
   b) Height: 50 – 100 feet
Causes of Volcanic Activity

a) **Diverging oceanic-oceanic crust**
   1) **Ridges** and rifts may contain volcanoes and hydrothermal vents.
Causes of Volcanic Activity

b) Converging oceanic-oceanic crust

1) Water bearing minerals, brought down with the subducting plate causes the rock to melt and get hotter than the surrounding material.

2) This magma rises through the overlying crust and creates deep sea volcanoes.

a) These volcanoes grow and grow sometimes forming islands.
Causes of Volcanic Activity

c) Converging *oceanic-continental* crust

1) As the *subducting* plate is pulled deeper into the upper *mantle* the plate begins to melt and rises as magma intrusions.

a) Builds *mountains* on the surface of the overlying *continental* crust.
Volcanic Mountain Chains
Volcanoes

2) The **Ring of Fire**
Hot Spots

3. Results from the slow movement of a tectonic plate across a hotter point in the mantle deep beneath the surface of the crust.

1) Can be caused by a narrow stream of hot magma convecting up from the Earth's core-mantle boundary a) called a mantle plume.

2) Upper-mantle convection
b) Hawaiian Islands
Volcano Anatomy

Main Features of a Volcano

- Ash Cloud
- Pyroclastic Flow
- Volcanic Bombs
- Crater
- Main vent
- Lava Flow
- Secondary Cone
- Secondary Vent
- Magma Chamber
Types of Volcanoes

a) **Shield Cones**
   1) Non-explosive eruptions; built from repeated lava flows.
   2) Gently sloping sides

Mauna Loa, Hawaii
Types of Volcanoes

b) **Cinder Cones** - **Explosive** eruptions
   1) Built from **tephra** (volcanic **cinders** and **ash**.)
   2) **Steeply** sloping sides

![Cinder Cone Volcano](image)

Paricutin, Mexico
c) **Composite Cones** - Repeated non-explosive and explosive eruptions;

1) **alternating** layers of lava and **tephra**.
2) **Moderately** sloping sides
Types of Volcanoes
Volcanic/ Plutonic Features
Historical Perspective

- Choose a historical earthquake or volcanic eruption and describe or illustrate what it would feel like to live near by.
  - What did you hear or see?
  - What was your home like?
Connecting Ideas

![Diagram of Earth's layers](image-url)
### Surface Processes & Landscapes

**Strategy:** Activating Cognitive Schema  
**Modes of Communication:** Descriptive, pictorial

**Rational:** As students explore what they know about a new topic and how they may identify with it, they are required to activate the schema necessary to continue learning about the topic at hand. This strategy creates a pathway for deeper understanding and learning, as ideas are scaffolded throughout the notes. By activating prior knowledge and communicating that knowledge in several different ways students learn to reflect on their understanding of the topic before it is introduced.

**Location(s):**  
Page 1, Slide 2

**Reference:**  
Thinking Questions; Kagan (1999)

---

**Strategy:** Summative Cognitive Reflection  
**Modes of Communication:** Descriptive, textual

**Rational:** Throughout the note-packets students are asked to copy and create several drawings. Summative descriptive strategies provide students with the opportunity to combine the main ideas and drawings from within the lecture; into a cohesive statement of understanding. Through this process students and teachers can monitor how students make connections between new ideas and previous knowledge. These strategies provide insight into student comprehension and perception of segmented and holistic scientific systems and processes.

**Location(s):**  
Page 21, Slide 70

**Reference:**  
Think Trix;, Kagan (2005)
<table>
<thead>
<tr>
<th>Strategy:</th>
<th>Summative Cognitive Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Depictive, symbolic, textual</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>Units within the Earth Science curriculum, introduce students to major ideas about the physical world around us with tremendous amounts of detail. Students must understand these details to properly communicate the broader ideas within a unit. Summative depictive strategies provide students with the opportunity to work through and review the textual information within their notes. As they review these new ideas and relationships students illustrate their thinking processes through graphic organizers or mind mapping tasks. These strategies allow teachers and students to visualize connections that students are making with new information and promote discussion and assessment of internal comprehension.</td>
</tr>
</tbody>
</table>
| **Location(s):** | Page 7, Slide 23  
Page 16, Slide 54  
Page 26, Slide 88 |
| **Reference:** | Thompson & Thomason (1999)  
Graphic Organizers; Kagan (1998)  

<table>
<thead>
<tr>
<th>Strategy:</th>
<th>Visual Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Descriptive, pictorial, iconic</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>Visual representations are meant to provide students with an illustration of an idea or word without demanding more from their working memory. Visual-descriptive strategies allow students to illustrate properties of an idea, rather than focus on the textual information. Student perceptions of the concept and its properties are prominent in this strategy. Teachers should allow students opportunities to revise or add to images created during note taking.</td>
</tr>
</tbody>
</table>
| **Location(s):** | Page 13, Slide 44  
Page 15, Slide 49  
Page 23, Slide 79  
Page 24, Slide 81 |
**Strategy:** Graphic Interpretation

**Modes of Communication:** Descriptive, pictorial

**Rational:** Throughout the Earth Science curriculum and within the NYS Regents exams students are expected to interpret information from and add information to a multitude of diagrams. Within the graphic-descriptive strategy students are asked to analyze diagrams for information and add or pull information from the diagrams based on information provided within the unit. The use of this strategy affords teachers with the opportunity to nurture the use of diagrams, and provides students with a basis for the utilization of diagrams in science.

**Location(s):**
- Page 14, Slide 47
- Page 19, Slide 61
- Page 22, Slide 73
- Page 22, Slide 75
- Page 24, Slide 83
- Page 25, Slide 84

---

**Strategy:** Visual Interpretation

**Modes of Communication:** Depictive, pictorial, symbolic

**Rational:** Focusing on the textual information provided within the notes students create mental and physical images. The visual-depictive strategy will aid in the creation of mental models as note taking occurs. In each instance the student is asked to interpret the text and create an illustration that depicts their understanding. This creates an internal connection between the student and the concept, as well as supporting informal assessment techniques.

**Location(s):**
- Page 5, Slide 17
- Page 9, Slide 31, 32
- Page 11, Slide 37&38
- Page 16, Slide 53
- Page 18, Slide 59
<table>
<thead>
<tr>
<th><strong>Strategy:</strong></th>
<th>Mathematical Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Depictive, pictorial, symbolic</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>Mathematical-symbolic strategies focus on the development of simple graphic images to represent the relationships between two or more variables. The development of each instance varies from linear to axial locations and labels. Each variation was chosen to draw the attention to the specific variables and how each behaves in relation to one another. Students and teachers should engage in scientific discourse as the relationships are identified and represented.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
<td>Page 8, Slide 25, 26</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th><strong>Strategy:</strong></th>
<th>Mathematical Interpretation</th>
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</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Symbolic, textual</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>Several equations are used throughout the curriculum to aid in student understanding of illustrated or observed data. These common place equations, in Earth Science, are spread throughout the presentations to provide students with multiple opportunities to practice manipulating and communicating information using the variables and units of measure associated with gradient, rate of change and eccentricity formulas.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
<td>Page 25, Slide 86, 87</td>
</tr>
</tbody>
</table>
I. Weathering – The ____________ and ______________ break down of ______
into smaller pieces called ________________.

1. Ranging in sizes from -/+ 0.00001 _____ to 25cm

A. Two methods of weathering:

1. Physical - Physical ______________ break down rock into smaller and smaller
__________________________, involving no chemical change.

   (1) Mechanical weathering: _______________________________

       __________________________________

       __________________________________

   a) Causes of Physical Weathering –

   (1) ________________________________ - Exfoliation

      (a) Rocks are heated by the sun; causing the ____________

          rock layer to ________________.

      (b) As temperatures _______________ at night, rocks ___________

         and ________________.
(c) This __________ of heating and cooling causes the surface of the rock to break off in ________________.

(2) __________________________ - Frost Wedging

(a) ___________ seeps into the ___________ of rocks, when the water __________ it ___________ and later melts, only to freeze again.

(b) This cycle of ___________________________ causes the rocks to ___________________________.

(3) __________________________ - Plant roots

(a) ___________ roots and some shrubs grow through the ___________ in rocks.

(b) Moss and lichen use mineral grains to take root.

(4) ___________ / ___________ - Abrasion

(a) Water - Sediments carried by ___________, collide into each other and the ___________.

(1) ___________ and ___________

(b) Wind - blown particles ___________ into each other and the surrounding rock.

(1) ___________ and ___________

2. Chemical - Any process that causes rock to break down by __________________________ and results in a ___________ in the mineral/chemical __________________________.

(1) Chemical Weathering: __________________________

_________________________

_________________________
b) Causes of Chemical Weathering –

(1) Carbonation- __________ (in the atmosphere) ______________ in the water droplets that make up __________.

(a) A weak carbonic __________ forms.
(b) Some rocks and minerals __________ with carbonic acid.

(2) Hydration- __________ dissolves certain rock forming minerals.

(a) ________________ weathers into ____________ when dissolved by water, causing the rock to ________________

(b) Other minerals, like ________________, are left behind as ____________ or other sized sediment.

(3) Oxidation- when ________________ from the atmosphere ________________ with certain elements.

(a) ________________ + Oxygen = Iron Oxide (______________)

(b) Causes corrosion and ________________ of rock.

(4) ____________ Acids · weak ____________ produced by plants can dissolve minerals in the rock; making the rock ________________.

(5) ____________ acids · ____________ produced by industries, can dissolve into the water droplets of a cloud to produce ________________

(a) H₂SO₄ – Sulfuric Acid,  HNO₃ – Nitric Acid

3. Rates of Weathering – Time and products of weathering depend on many different variables.

a) ________________ · the ________________ factor that affects the rate of weathering and ________________ features.
(1) Temperature:

(a) Warmer climates; more ________________ action.

(b) Colder climates; more ________________ action.

(2) ________________:

(a) ________________ precipitation; more frost action.

(b) Increased precipitation; more ________________ weathering.

(3) Landscapes: ________________ and different ________________ processes cause landscapes to develop differently.

(a) ________________ weathering is most rapid in warm,

moist/______________ climates.

(i) ________________

(b) ________________ weathering is more common in dry/_______

climates.

(ii) ________________

b) ________________ Weathering -

(1) ________________ types of ________________ cause differential weathering.

(a) Softer, less weather-______________ rocks wear away.

(b) Leaves harder, ________________ weather-resistant rocks behind
4. ___________________ of Weathering – Sediment & Soil

a) Sediment –

(1) Solid ___________________ of ___________________ and organic material that come __________ the ___________________ of rock which are eroded and _________________ by wind, _________ or ice.

(2) Sediment names: Boulders, _______________ pebbles, sand, _______________ clay
(3) Sediment Sizes: ESRT's pg __________

<table>
<thead>
<tr>
<th>Name of Sediment</th>
<th>Size (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulders</td>
<td></td>
</tr>
<tr>
<td>Cobbles</td>
<td></td>
</tr>
<tr>
<td>Pebbles</td>
<td>6.4 cm -</td>
</tr>
<tr>
<td>Sand</td>
<td></td>
</tr>
<tr>
<td>Silt</td>
<td>0.006 cm -</td>
</tr>
<tr>
<td>Clay</td>
<td>Less than 0.0004 cm</td>
</tr>
<tr>
<td></td>
<td>Less than 0.0001 cm</td>
</tr>
</tbody>
</table>

Relationship of Transformed Particle Size to Water Velocity

b) Soil -

(1) Combination of _________________ rock and organic matter.

   (a) _________________ plant and animal material found in soil.

(2) Soil develops over _________________, through _________________ processes.

(3) _________________ vs. Transported Soil

   (a) Residual - The soil formed in its current location.

      (i) The bedrock _________________ the rock fragments in Horizon C.

   (b) _________________ - soil formed in a different area

      and was deposited in its current location; does not match up with rock fragments in _________________.
II. Erosion & Deposition –

A. ________________: the process by which weathered ________________ are carried or ________________.

1. A __________ or ________________ sediment from one place to another
   a) Running __________, waves, __________, glaciers, and __________

B. ________________: the process by which ________________ is dropped or ________________.

1. Deposition can occur when:
   a) ________________
   b) The ________________ of running water (or wind) decreases.
   c) The discharge/______________ of water decreases.
C. Factors that affect the rate of erosion & deposition:

1. Size - As the __________ of a sediment ________________, the __________
   (speed) of deposition ________________, and erosion ________________

2. Density - As the density of a sediment increases, the rate of deposition will
   ________________, and ________________ will ________________

3. Shape - As a sediment becomes more ________________, the rate of deposition
   will ________________, and ________________ will ________________

D. Agents of Erosion & Deposition:

1. Gravity - a downward ________________ acting on all sediments; __________
   sediments down slopes.

   a) Erosion - ________________

      (1) The ________________ of sediments by ________________

         (a) Landslides, mudslides, ___________, etc...

   b) Deposition that results- ________________

      (1) ________________ sediment found at the __________

          of steep ________________ walls/__________.

   c) ________________ may act alone or with other transporting ______

      (1) Gravity causes:

         (a) Water to flow ________________

         (b) ________________ to flow down a ________________ or

              spread ________________

         (c) Winds; by pulling ________________ air underneath

              ________________ air.
2. Wind – The horizontal movement of air along Earth’s surface; due to changing air

   ________________________

   a) Erosion:

   (1) The amount of wind ____________________ depends on particle size, wind

       speed & ________________________________

   b) Deposition:

   (1) Well __________________ and __________________ sediments

   c) Weathering:

   Causes ______________________ rock surfaces, and angilar ______ ____________.

III. Running Water – The __________________ form of __________________

   A. Rain:

   1. When precipitation falls onto Earth’s surface, several things can happen to the water.

   a) __________________: water __________________ land, to bodies of water

   b) __________________: water __________________ the ground

   c) __________________ & __________________

   d) Stored in ponds/lakes and __________________
B. Rivers & Streams

1. _____________________ Basin: ____________________________

   a) The area of land drained by a ____________________________

   (1) River System: a main river and its ____________________

        (a) Tributaries: a smaller ______________ that ____________ into

        a __________ one.

   (2) NYS Watersheds:

<table>
<thead>
<tr>
<th>Letter</th>
<th>Watershed</th>
<th>Main River</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>St. Lawrence</td>
</tr>
<tr>
<td>B</td>
<td>Susquehanna</td>
<td>Chesapeake</td>
</tr>
<tr>
<td>C</td>
<td>Mohawk</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Champlain</td>
<td>St. Lawrence</td>
</tr>
<tr>
<td>H</td>
<td>Allegheny</td>
<td>Ohio</td>
</tr>
<tr>
<td>I</td>
<td>Erie</td>
<td>St. Lawrence</td>
</tr>
</tbody>
</table>

   (3) Stream Drainage _____________________ & ______________________

        (a) Radial: From the top of a circular volcano or dome ____________

        (b) Rectangular: ____________, tilted or folded strata.

        (c) Annular: A dome with upturned layers.

        (d) Dendritic: Usually found on flat laying strata or uniform bedrock of

               uniform type.
2. Stream Factors That Cause __________

   a) ______________ of water

   (1) The volume (____________) of water in a stream is its ______________

   (2) As ______________ increases, the rate of erosion also ______________.
(3) Factors that affect volume

(a) __________________: Spring Vs Fall; usually greater volume in the ___________.

(b) Climate: __________ vs __________: usually __________

volumes in humid climates.

(c) Weather: daily changes in ______________ affect

the volume of a stream.

(d) ____________ / ____________: Saturated vs. ______________;

greater volume/discharge around ______________ soil.

b) __________________ of water

(1) Stream velocity describes how __________ the water is moving

______________________________

(2) As the ______________ of a stream increases; the rate of erosion also

____________________.

(3) Factors that affect stream velocity

(a) ______________: how quickly ___________________ changes.

(i) As gradient/elevation increases; stream ______________

will ________________.

(b) Volume: how much water flows passed a certain point.

(i) As the ______________ of a stream increases; stream

velocity will also ________________.

c) Stream ______________: the ___________ that a stream follows

(1) When a stream flows through its channel; its ______________ will change

due to the ______________ /shape of the channel.

(a) The curves/___________ in a stream channel are called

____________________.
2. Stream Channel Erosion -

(a) At the _______________ of the curve, the streams _______ ________________, therefore ________________ occurs.

(b) At the _______________ of the curve, the streams _______ ________________, therefore ________________ occurs.

3. Streams and sediment transport

a) Stream load: the amount of ________________ that a stream can
   "______________".

b) Types of stream transport:

(1) ________________: minerals ________________ in water.

(2) Suspension: small particles carried ________________

(3) ________________: larger particles rolling and bouncing ________________
4. Stream Deposition Patterns:

(a) **Running Water: Stream**

(1) When one body of water enters another, its ________________ will ________________, therefore the ________________ of ________________ occurs.

(2) Deltas - A deposit at the ________________ of a stream, where a river/stream enters a ________________ body of water.

(3) Sediment Deposits:

(a) Horizontal: bigger more dense sediment deposits ________________ to the mouth of a river, followed by smaller, less ________________ sediment further out.
(b) Vertical: Bigger, heavier sediment deposits __________ and settles to the bottom, smaller sediment is deposited on top in decreasing size.

b) ________ Fans: stream deposition on land

5. Stream Landscape Features: Youthful, Mature, Old
   a) Youthful: Increased erosion, _______________ channels, no meanders.
   b) Mature: Floodplains, multiple ____________, broader channels
   c) Old: Meandering, slow moving, shallow, broad floodplains, with _________ lakes
The Formation of an Oxbow lake: ______________ & ___________
IV. Glaciers – large masses of ____________________________

A. Types of Glaciers:

1. _______________ / Alpine –
   
   a) Form in mountain ________________________________

      (1) Ex: __________, Rockies, Himalayas, ________________

2. Continental –
   
   a) Form over vast ________________________________

      (1) Ex: __________________________, __________________________

B. Glacial Erosion & Deposition:

1. Valley Glaciers –
   
   a) The _______________ moves __________________________ the sides.

      (1) There is more _______________ on the ___________ of the glacier, where the ice meets valley walls.

      (a) Causes side advancing motion to _______________, and __________________ of the rock walls.

   b) Erosion – freezing and __________________________

      (1) _______________ are _______________ and carried in the __________ as the glacier ____________________.

      (2) Erratic: A _______________ found near no other rocks.

   c) Deposition – Sediments are dropped during thawing/________________

      (1) Moraine: _______________ rock material is carried and _______________

      by a glacier as it retreats/______________.
(a) Lateral: unsorted rock on the __________, along the valley ____________.

(b) Medial: unsorted rock _______ the glacier in the __________

   (i) Resulting from the __________ of two smaller valley glaciers.

(c) Ground: ___________ rock __________ underneath the glacier.

(d) ___________/End: unsorted rock trapped at the __________

_________; "end" of the glacier

2. Landscape features resulting from glacial erosion & d

   a) Valley ___________ – Stream & River Valleys Vs. Glacial Valleys

      (1) Streams & Rivers:

         (a) Create _______________ valleys, due to waters' ability to erode and cut into rock.

      (2) Alpine Glaciers:

         (a) Create _______________ valleys, due to ice pushing sediment forward, as it _______________
(b) Continental Glacial Features –

(i) ___________ - a cone-shaped hill made of sediment carried to the edge of a glacier by melt water.

(ii) ___________ - an oval shaped hill of glacial moraine.

(iii) ___________ - large boulder deposited by ice

(iv) ___________ - a lake formed when a block of glacial ice melts.

(v) ___________ - a stream that is divided into an interlocking system of channels.

(vi) ___________ - layers of sediment deposited by the meltwaters of glacial ice.

(vii) ___________ - loose rock carried by a glacier and finally deposited in the form of a ridge or belt.

- It marks the farthest point reached by the glacier.

(viii) ___________ - glacial material deposited as the glacier retreats.

(ix) ___________ - a ridge-like hill of deposits resulting from a stream flowing in a tunnel under the glacier.
C. Ice ages: continental glaciers

1. There is evidence of at least ______ major _______期间 during the last _______ years.
   a) The most recent ice age ended _______ years ago.

2. Local landscapes affected by glacial erosion & deposition
   a) Genesee River: redirected by glacial melt waters and flows into _______; a glacial lake.
   b) Niagara Falls: started as a waterfall by the town of _______

   (1) Throughout geologic time the falls have moved _______ towards _______.

   (2) As the falls _______ through the bedrock, certain layers have been eroded more than others; due to _______ weathering.
c) **Great Lakes** - formed during ancient ice ages from

1. H.O.M.E.S.

![Great Lakes Profile](image)

---

d) **Finger Lakes** - formed during the last ice age from


![Finger Lakes Map](image)
D. Mapping Landscapes – Field Maps

1. ___________ - a region of space or an _________ that has a measurable ___________, of a given property, at every _____________.
   a) ___________ - lines on a field map
   all the points of the _____________.

2. ___________ Maps - Elevation Fields - Show the ___________ of the land by using contour lines.
   a) Elevation: the distance ___________.
   b) ___________ line - Isoline on a map connecting points of the same ___________.

1) Elevation at A: ___________
2) Elevation at B: ___________
3) Elevation at C: ___________
c) Contour lines - The two consecutive contour lines.

(1) ________________ Contour Line - Heavy, ________________ contour line, usually with numerical value for elevation ________________.

(2) ________________ Contour Line - indicate a hole or ________________ on the surface.

(a) Marked inside: ________________ marks

a) Contour Interval: ________________
b) Highest Possible elevation: ________________
c) Steepest Side: ________________

(3) The ________________ Contour lines ________________

__________________ ; where they cross a river.
* indicates the ________________ the river is ________________

---

d) Basic Features and Topographic Map Symbols

(1) Elevation

(2) Steepness/ ________________

(3) Shape of the land
(4) Bench Mark (________) - Marker ______________________ indicating the ______________ elevation above sea level.

(5) __________ Elevations – elevations of intersections, hilltops, lakes...
   - Marked with a ________________.

(6) Natural and man-made feature symbols.

**e) Drawing Contour Lines**

20, 40, 60, 80, 100, 120 feet

Scale of Miles
Creating a __________ of a Topographic Map

- Place a sheet of scrap paper on the map; connecting points A and B.
- Mark the location and value of each contour line that intersects with your scrap paper.
- Move scrap paper to bottom of graph, mark the values of the lines from their exact locations on the scrap paper.
- Connect points with a smooth line.

---

9) __________ · the __________ at which elevation __________

between two locations

(1) Formula:

(2) Calculate gradient between the following points

(a) AC

(b) BD

(c) BE

(d) FC
Radial: A circular volcano or dome mountain.
EX: the rim of The Adirondacks

Rectangular: Faulted, tilted, or folded strata.
EX: Finger Lakes, Central Adirondacks

Annular: Dome with upturned layers.
EX: Esopus Creek, NY Black Hill, SD

Dendritic: Usually found on flat lying strata or uniform bedrock type.
EX: Appalachian Plateau, NY
Surface Processes & Landscapes
Landscapes

- What things to you think of when you think of landscapes?
  - Draw or describe a landscape
  - How did your landscape form?
  - What surface processes effect/effected your landscape?
Weathering

1. The **physical** and **chemical** break down of **rock** into smaller particles called **sediment**.
   - Ranging in size from $\pm 0.00001$ cm – $25+$ cm

   - Two types of weathering
     - Physical – wind, water, sand, temp changes, organic activity, etc…
     - Chemical – acids, water, rusting, corrosion, etc…
Physical Weathering

1. Physical **forces** break down rock into smaller and smaller **fragments**, involving no chemical change.
   1) Also called mechanical weathering
      - **exfoliation, frost action, cracks, abrasion**, etc…
Causes of Physical Weathering

1. **Temperature Changes** – Exfoliation
   a) Rocks are heated by the sun; causing the **outside** layers to **expand**.
   b) As temperature **decrease** at night, rocks **cool** and **contract**
   c) This **cycle** of heating/cooling causes the surface of the rock to break off in **slabs/layers**.
Causes of Physical Weathering

2) **Frost Action**—Frost Wedging / Hydrofracturing
   a) **Water** seeps into the **cracks** of a rock, when the water **freezes** it **expands**, and later melts.
   b) This cycle, of **freezing and thawing** causes the rocks to **break apart**.
   • Main cause of potholes and winter road damage.
Causes of Physical Weathering

3. **Organic Activity** – Plants
   a) **Trees** and some shrubs grow through **cracks** in rocks.
      • Moss and lichen use the grains of rocks to take root.
Causes of Physical Weathering

4. **Water/Wind - Abrasion**
   a) Water- sediments carried by *streams* collide into each other and the *river bed (rounded, smooth)*
   b) Wind- blown particles *collide* into each other and the surrounding rock *(angular, rough)*
Chemical Weathering

2. Any process that causes rocks to break down by chemical action and results in a change in the mineral/chemical composition.

- carbonation, hydration, oxidation, plant and man made acids, etc…
Causes of Chemical Weathering

1) Carbonation – \(\text{CO}_2\) (in the atmosphere) **dissolves** in the water droplets that make up **clouds**.
   a) Forming a weak carbonic **acid**.
   b) Carbonic acid **reacts** with some rocks and minerals.
      i. **Calcite**
      ii. **Limestone**
      iii. **Marble**
Causes of Chemical Weathering

2) Hydration - When water dissolves certain minerals in rock.
   a) The mineral feldspar weathers into clay when dissolved by water; causing the rock to break apart.
   b) Other minerals, like quartz, are left behind as sand or other size sediments.
   • Dissolved Minerals: cause the “hardness” in ground and surface water
Causes of Chemical Weathering

3) Oxidation - when oxygen from the atmosphere combines with certain elements
   a) Iron + Oxygen = iron oxide (rust)
   b) Corrosion, crumbling

4) Plant Acids - Weak acids produced by plants can dissolve minerals in rock; making the rock weaker
Causes of Chemical Weathering

5) **Man/Earth-Made Acids - Gases**
produced by industries can dissolve in the water droplets of a cloud to produce **acid rain**.

- $\text{H}_2\text{SO}_4$ - Sulfuric Acid
- $\text{HNO}_3$ – Nitric Acid
Rates of Weathering

a) **Climate** is the **major** factor that affects the rate of weathering and **landscape** features

1) **Temperature**
   a) warm climates; more **chemical** action
   b) In cold climates; more **frost** action

2) **Precipitation**
   a) **Increased** precip.; more frost action
   b) Increased precip.; more **chemical** weathering

- Chemical weathering is most rapid in warm, moist climates.
Landscapes

3. Due to **climate** and different **weathering** processes, landscapes develop differently.

a) **Physical**: **Arid** Climate
   i. Arizona

b) **Chemical**: **Humid** Climate
   ii. Brazil
b) **Differential Weathering**

1) **Different** types of **rock** cause differential weathering.
   a) The process by which softer, less weather-resistant rocks wear away.
   b) Leaves harder, **more** weather resistant
      - Most resistant?
      - Least resistant?
2) Surface Area Vs. Particle Size

a) **Weathering** takes place on the *outside* surface of rocks.

b) The more surface area that is *exposed*, the *faster* the rock will be *broken down*.

c) As a rock breaks into *smaller* pieces, the *surface area* increases
   i. therefore, the *rate* of weathering *increases*
Products of Weathering

a) Sediment

1) Solid fragments of inorganic or organic material that come from the weathering of rock; which are carried/eroded and deposited by wind, water, or ice.

2) Boulders, cobbles, pebbles, sand, silt, clay, and colloids
   • Colloids are very small solid sediment, that are too small to be seen with an ordinary microscope, and too light to settle in water.
### Sediment Sizes

ESRT’s pg 6

<table>
<thead>
<tr>
<th>Name of Sediment</th>
<th>Size (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulders</td>
<td>25.6 cm – +</td>
</tr>
<tr>
<td>Cobble</td>
<td>6.4 – 25.6 cm</td>
</tr>
<tr>
<td>Pebbles</td>
<td>6.4 – 0.2 cm</td>
</tr>
<tr>
<td>Sand</td>
<td>0.2 – 0.006 cm</td>
</tr>
<tr>
<td>Silt</td>
<td>0.006 – 0.0004 cm</td>
</tr>
<tr>
<td>Clay</td>
<td>Less than 0.0004 cm</td>
</tr>
<tr>
<td>Colloids</td>
<td>Less than 0.0001 cm</td>
</tr>
</tbody>
</table>
Soil

1) Combination of *weathered* rock and organic matter
   a) **Humus**: decayed plant and animal material found in soil.
      • 20-30% - rich soil.

2) Soil develops over **time**; through **weathering** processes
Residual vs. Transported

a) If the bedrock matches the rock fragments of the C-horizon, the soil is most likely residual.

b) The soil was most likely transported to that area, if the bedrock does not match the soil composition.
Soil Layers

4) Soil Profile

- **Topsoil** or **A horizon**: more humus than other layers
- **Subsoil** or **B horizon**: contains clays and dissolved minerals *leached* from above
- **C horizon**: contains weathered rocks, usually from bedrock

**Bedrock**: layer of rock below
• Illustrate the formation of soil over time; choose an organizer to show growth and processes over time.
Erosion & Deposition

A. **Erosion:** The process by which weathered *sediments* are carried/transported.
   1. A **force** or **material can move** sediments from one place to another.
      a) Running **water** or waves, **wind**, glaciers, and **gravity**

B. **Deposition:** The process by which **sediment** is dropped or **settles**.
   1. Deposition occurs when:
      a) erosion stops/slow
      b) the **velocity** of running water (or the wind) decreases.
      c) The discharge/ **volume** of water decreases.
Factors that Affect Deposition Rate

1. Size - As the size of a sediment increases, the rate (speed) of deposition increases and erosion decreases.

2. Density - As the density of sediment increases the rate of deposition increases and erosion decreases.
Factors that Affect Deposition Rate

3. Shape - As the shape of sediment becomes more **spherical**, the rate of **deposition** will increase and erosion will decrease.
Agents of Erosion & Deposition

1. Gravity – a downward **force** acting on all sediments. **Pulls** sediments down slopes

a) Erosion - **Mass wasting**:
   1) the **downhill movement** of sediments by **gravity**
      a) Landslides, mudslides, creep…

b) Deposition results: **Talus**
   1) **unsorted** sediment found at the **bottom** of steep bedrock walls/cliffs
Gravity

[Images of geological phenomena, including landslides and debris flows.]
The Underlying Force: Gravity

c) **Gravity** may act alone or with another transporting **agent**.

1) Gravity causes...
   a) Water to flow **downhill**
   b) **Glaciers** to flow down a **valley** or spread **outward**
   c) Winds; by pulling heavier **cold** air down beneath lighter **warm** air. (density)
Erosion & Deposition

2. Wind – the horizontal movement of air along Earth’s surface; due to changing air \textit{temperatures}.

   1) Amount of wind \textit{erosion} depends on…
      • The size of the sediments being carried
      • The speed at which the wind is blowing
      • The \textit{amount of time} that the wind continues to blow

b) Deposition results:
   i. Well sorted, tilted sediments

c) Weathering: \textit{rough} and angular \textit{fragments}
Erosion & Deposition

III. Running Water - The **dominant** form of **erosion** (besides gravity)

A. Rain

1. When rain falls onto Earth’s surface, several things can happen to the water:

   a) Runoff - flows over the land to bodies of water
   b) Infiltrate - water *sinks into* the ground
   c) Evaporate, transpiration
   d) Stored in ponds/lakes, and **underground**
Water on Land

- ...
Running Water – Erosion

- Rivers and Streams

<table>
<thead>
<tr>
<th>Major Rivers of the World</th>
<th>River Discharge at Mouth (km³/s)</th>
<th>Drainage Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amazon</td>
<td>0.180</td>
<td>6,150,000</td>
</tr>
<tr>
<td>Congo</td>
<td>0.041</td>
<td>3,720,000</td>
</tr>
<tr>
<td>Yangtze</td>
<td>0.035</td>
<td>1,810,000</td>
</tr>
<tr>
<td>Ganges</td>
<td>0.020</td>
<td>1,480,000</td>
</tr>
<tr>
<td>Mississippi</td>
<td>0.018</td>
<td>3,240,000</td>
</tr>
<tr>
<td>Nile</td>
<td>0.0028</td>
<td>3,035,000</td>
</tr>
</tbody>
</table>

Top 10 Rivers = 0.394 km³/s
Rivers & Streams

1. **Drainage Basin**: watershed
   a) The area of land drained by a river system.

   1) The main river and all of its tributaries
   a) Tributary: A smaller stream that flows into a larger one.
## NYS Watersheds

<table>
<thead>
<tr>
<th>Letter</th>
<th>Watershed</th>
<th>Main River</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Ontario</td>
<td>St. Lawrence</td>
</tr>
<tr>
<td>B</td>
<td>Susquehanna</td>
<td>Chesapeake</td>
</tr>
<tr>
<td>C</td>
<td>Mohawk</td>
<td>Hudson</td>
</tr>
<tr>
<td>E</td>
<td>Champlain</td>
<td>St. Lawrence</td>
</tr>
<tr>
<td>H</td>
<td>Allegheny</td>
<td>Ohio</td>
</tr>
<tr>
<td>I</td>
<td>Erie</td>
<td>St. Lawrence</td>
</tr>
</tbody>
</table>
Stream Drainage Patterns & Landscapes

a) Radial: from the top of a circular volcano or dome mountain

b) Rectangular: uplifted, tilted or folded strata

c) Annular: from a dome with upturned layers

d) Dendritic: found on flat lying land/strata or uniform bedrock with uniform composition
Stream Drainage Patterns & Landscapes

1. Landscape | Topographic Map
2. Landscape | Topographic Map
3. Landscape | Topographic Map
4. Landscape | Topographic Map
Drainage Patterns
Stream Factors that Cause Erosion

a) **Volume** of Water:
   1) The volume (amount) of water in a stream is called the stream’s **discharge**.

2) As the volume of water/discharge increases; the rate of erosion **increases**.
3) Factors that affect volume/discharge

a) **Seasons**: Spring vs. Fall; usually greater volume in the **spring**

b) **Climate**: Arid vs. Humid; usually **greater** volume in humid climates

c) **Weather**: Daily changes in **precipitation** affect the volume of a stream

d) **Ground/Soil**: Saturated vs. **Unsaturated**; greater volume when the soil is **saturated**.
Stream Factors that Cause Erosion

b) **Velocity** of Water:
   1) Stream velocity describes how fast the water is moving **passed a certain point**.

   2) As the **velocity** of a stream increases, the rate of erosion **increases**.
3) Factors that affect stream velocity

a) Gradient: how quickly elevation changes
   i. As gradient/elevation increases; stream velocity will increase.

b) Volume: How much water flows passed a certain point
   i. As volume/amount of water increases; stream velocity will increase.
Stream **Channels**

- Channel: the **path** that a stream follows
  - When a stream flows through its channel, its **speed** will change due to the **curvature** of the channel.

- **The bends** in a stream’s channel are called **meanders**.
Stream Channel Erosion

Key:

- Deposited stream sediment
- $X$ = Location of maximum Velocity

a) At the outside of the curve, the streams velocity increases, therefore, erosion occurs.

b) At the inside of the curve, the streams velocity decreases, therefore, deposition occurs.
Stream Equilibrium

a) Equilibrium: Erosion = Deposition
Streams and Sediment Transport

a) Stream Load: how much/ how heavy of a sediment can the stream “carry”

b) Types of Stream Transport
   - Solution – minerals dissolved in water
   - Suspension – small particles carried within the water
   - Saltation – larger particles rolling and bouncing along the bottom
Particle Size vs. Stream Water Velocity

ESRT’s Pg 6

i. What is the largest size sediment that can be transported by a stream in which the water velocity is:

a) 10 cm/s
b) 50 cm/s
c) 200 cm/s
Running Water – Deposition

(a) **Velocity**

1) When a stream enters a body of water, its **speed will decrease**, and therefore, the **deposition of sediment** occurs.

2) A deposit at the **mouth** of a stream where it enters a **large** body of water is called a delta.
Sediment Deposits

a) Horizontal: bigger more dense sediment deposits closer to the mouth of a river, followed by smaller, less dense sediment further out

b) Vertical: Bigger, heavier sediments deposit first and settle to the bottom, smaller sediment is deposited on top in decreasing order
Alluvial Fans

Stream deposition on land can also occur. This deposit is called an alluvial fan.
Stream Development

Note the features of this young stream:
- Flows swiftly
- Rapids/waterfalls
- **Shallow** channels

Forrested point bar cut by meandering stream

OLD Stream
- Flows slowly
- large floodplain
- **oxbow lakes**

Erodes on Sides
- **Meanders** form
- Broad channels
Stream Landscape Features
Formation of an Oxbow Lake

- The work of **erosion** and **deposition**
Connecting Strategies

- Identify three agents of erosion and deposition currently shaping the landscape you drew earlier.
Glaciers

IV. A glacier is a large mass of moving ice and snow.

A. Types of Glaciers

1. Valley/Alpine glaciers
   a) form in mountain valleys at high elevations
      1) Alps, Rockies, Himalayas, Andes

2. Continental glaciers
   a) form over vast areas of land
      1) Greenland, Antarctica
Valley Glaciers & Erosion

1. Valley Glacier – Movement
   a) The **center** of the mass moves **faster than** the sides.
   1) There is more **friction** on the **sides** of the glacier where the ice meets rock
      a) causes advancing motion to **slow down** and **erosion** of the rock walls
b) Erosion- freezing and **thawing**

1) **Sediments** are **plucked** out and carried in the **ice** as the glacier **advances**.
2) Erratic: A **boulder** found near no other rocks.

c. Deposition: Sediments are dropped during thawing/**melting**
Valley Glaciers & Deposition

1) Moraine: **Unsorted** rock material carried and **deposited** by a glacier as it retreats/melts
   a) Lateral Moraine: Unsorted rock on the **glacier** along the valley **walls**
   b) Medial Moraine: Unsorted rock on the glacier in the **central** region
      i. Resulting from the **merging** of two smaller valley glaciers
   c) Ground moraine: **Unsorted** rock trapped at the bottom of the glacier; leaves **striations** behind
   d) **Terminal/End** Moraine: Unsorted rock trapped at the **leading edge**; “end” of the glacier
Valley Glaciers
Erosion & Deposition

- How will the stakes on the glacier move over time?
Valley Shape

a) Streams create **V-SHAPED** valleys

a) Glaciers create **U-SHAPED** valleys as it advances
Continental Glacial Deposition Formations

1. Kame
2. Drumlin
3. Erratic
4. Kettle
5. Braided stream
6. Outwash plain
7. Terminal Moraine
8. Till
9. Esker
Alpine Glacial Formations

Arête
Horn
Tarn
Pater noster lakes
Cirques
Hanging valley
Glacial trough

C. Glaciated topography
Ice Age Continental Glaciers

• In the geologic past, much colder climates have resulted in sheets of ice covering much of Earth’s surface.
  1. There is evidence of at least 4 major ice Ages during the last 2 million years
    a) The maximum ice advance ended about 22,000 years ago.
Four Stages of Last Ice Age in the USA

- Wisconsin
- Illinoian
- Kansan
- Nebraskan
a) Genesee River: was redirected by glacial melt waters and flows into **Lake Ontario**; a glacial lake.
b) Niagara Falls: Started as a waterfall by the town of Lewiston

1) Throughout geologic time the falls have moved **south** towards Buffalo
2) As the falls “cut” through the bedrock, certain layers have been eroded more than others due to **differential** weathering.
c) Great Lakes: formed during ancient ice ages from **glaciers**

1) **H.O.M.E.S**

![Map of the Great Lakes](image)
a) Finger Lakes – formed during the last ice age from glaciers

1) Seneca, Cayuga, Keuka, Otisco, Owasco, Canadice, Canandaigua, Honeoye, Hemlock, Conesus, Skaneateles.
### Creative Writing

<table>
<thead>
<tr>
<th>Role</th>
<th>Audience</th>
<th>Format</th>
<th>Topic</th>
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</thead>
<tbody>
<tr>
<td>Early glacial Snowflake</td>
<td>Self</td>
<td>Journal</td>
<td>Journey</td>
</tr>
<tr>
<td>Erratic</td>
<td>Bedrock</td>
<td>Letter</td>
<td>Apology</td>
</tr>
<tr>
<td>Melt water</td>
<td>End Point</td>
<td>Poem</td>
<td>Erosion and Deposition</td>
</tr>
<tr>
<td>Mammoth</td>
<td>Future</td>
<td>Notes</td>
<td>Ice Age Observations</td>
</tr>
<tr>
<td>Ground</td>
<td>Glacier</td>
<td>Argument</td>
<td>Weight &amp; Support</td>
</tr>
</tbody>
</table>
Field Maps

1. **Fields** - Regions of space/area that has a measurable **value**, of a given property, at every **point**.

2. **Isolines** - Lines on a field map connecting all the points of the same value.
Field Maps

a) Property-
b) Iso**therm**
c) Temp for NYS-

d) Property – **Thunderstorms**
e) Iso**brunt**
f) Quantity for NYS-
Topographic Maps

2. Elevation Fields - Show the elevation of the land by using contour lines.
   a) Elevation: the distance (feet or meters) above sea level

b) Contour line – Isolines on a map connecting points of the same elevation
1) Elevation at A: 71-79 ~75
2) Elevation at B: 41-49 ~44
3) Elevation at C: 51-59 ~55
Contour Lines

c) Contour **Interval** - The **difference** in elevation **value between** two consecutive contour lines.

1) **Index** Contour Line - Heavy, **darker** contour line, usually with numerical value for elevation **marked**

• 10, 20, 100...
2) **Depression** Contour Line - Used to show a hole or **crater** on the surface.

a) Marked inside; **hachure** marks
Contour Maps

1. **Contour** line
2. **Depression**
   - Hachure
3. **Index** line

a) Contour Interval:
b) Highest Possible elevation:
c) Steepest Side:
   - lines are closest together
3) The **Law of the V’s** - Contour lines **bend upstream** where they cross a river.

- Indicates the **direction** the river is **flowing**.
Basic Features

1) Elevation

2) Steepness/gradient

3) Features of the area
Common Map Symbols

4) Bench Mark (B.M.) - Marker in the ground indicating the exact elevation above sea level.

5) Spot elevations - Elevation of intersections, hilltops, lakes...
   4) Marked with a + or x

6) Natural and man-made feature symbols.

1. [Image] = House/Building
2. [Image] = barn/garage
3. [Image] = church
4. [Image] = School
5. [Image] = Swamp
6. [Image] = railroad
7. [Image] = Cemetery
8. [Image] = gravel pit, quarry/mine
Drawing Contour lines

20, 40, 60, 80, 100, 120 feet

OCEAN

Scale of Miles
Creating a **Profile** of a Topographic Map

- Place a sheet of scrap paper on the map; connecting points A and B.
- Mark the location and value of each contour line that intersects with your scrap paper.
- Move scrap paper to bottom of graph, mark the values of the lines from their exact locations on the scrap paper.
- Connect points with a smooth line.
Identifying Profiles
Gradient/Slope

g) Gradient - The rate at which elevation changes between two locations

1) Formula: Gradient = \text{change in field value} / \text{distance}

2) Calculate gradient between the following points
   a) AC
   b) BD
   c) BE
   d) FC
Calculating Gradient

a) Example: AC

- Δ field value
  110 – 20 (ft)
- Distance
  3.5 mi
- Gradient
  90 ÷ 3.5 =
  25.7 ft/mi
Connecting Main Ideas & Thoughts

- Create a mind map to show the relationships between weathering, erosion, deposition and the landscape that develops as a result of these processes.
  - Include details, drawings, examples, map views
Earth’s History

**Strategy:** Activating Cognitive Schema

**Modes of Communication:** Descriptive, Pictorial

**Rational:** As students explore what they know about a new topic and how they may identify with it, they are required to activate the schema necessary to continue learning about the topic at hand. This strategy creates a pathway for deeper understanding and learning, as ideas are scaffolded throughout the notes. By activating prior knowledge and communicating that knowledge in several different ways students learn to reflect on their understanding of the topic before it is introduced.

**Location(s):**
Page 1, Slide 7

**Reference:**
Thinking Questions; Kagan (1999)

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**Strategy:** Summative Cognitive Reflection

**Modes of Communication:** Descriptive, textual, symbolic

**Rational:** Throughout the note-packets students are asked to copy and create several drawings. Summative descriptive strategies provide students with the opportunity to combine the main ideas and drawings from within the lecture; into a cohesive statement of understanding. Through this process students and teachers can monitor how students make connections between new ideas and previous knowledge. These strategies provide insight into student comprehension and perception of segmented and holistic scientific systems and processes.

**Location(s):**
Page 11, Slide 35, 36, 37, 38

**Reference:**
Thompson & Thomason (1999)
<table>
<thead>
<tr>
<th>Strategy: Visual Representations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong> Descriptive, pictorial, iconic</td>
</tr>
<tr>
<td><strong>Rational:</strong> Visual representations are meant to provide students with an illustration of an idea or word without demanding more from their working memory. Visual-descriptive strategies allow students to illustrate properties of an idea, rather than focus on the textual information. Student perceptions of the concept and its properties are prominent in this strategy. Teachers should allow students opportunities to revise or add to images created during note taking.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
</tr>
<tr>
<td>Page 7, Slide 29</td>
</tr>
<tr>
<td>Page 9, Slide 33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strategy: Graphic Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong> Depictive, pictorial, symbolic</td>
</tr>
<tr>
<td><strong>Rational:</strong> Throughout the Earth Science curriculum and within the NYS Regents exams students are expected to interpret information from and add information to a multitude of diagrams. Within the graphic-descriptive strategy students are asked to analyze diagrams for information and add or pull information from the diagrams based on information provided within the unit. The use of this strategy affords teachers with the opportunity to nurture the use of diagrams, and provides students with a basis for the utilization of diagrams in science.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
</tr>
<tr>
<td>Page 4, Slide 19</td>
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</table>

<table>
<thead>
<tr>
<th>Strategy: Visual Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong> Depictive, pictorial, symbolic</td>
</tr>
<tr>
<td><strong>Rational:</strong> Focusing on the textual information provided within the notes students create mental and physical images. The visual-depictive strategy will aid in the creation of mental models as note taking occurs. In each instance the student is asked to interpret the text and create an illustration that depicts their understanding. This creates an internal connection between the student and the concept, as well as supporting informal assessment techniques.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
</tr>
<tr>
<td>Page 2, Slide 10</td>
</tr>
<tr>
<td>Page 3, Slide 16, 17</td>
</tr>
<tr>
<td>Page 5, Slide 22</td>
</tr>
<tr>
<td>Page 6, Slide 26</td>
</tr>
<tr>
<td>Strategy: Mathematical Interpretations</td>
</tr>
<tr>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Modes of Communication: Symbolic, textual</td>
</tr>
</tbody>
</table>

**Rational:** Several equations are used throughout the curriculum to aid in student understanding of illustrated or observed data. These common place equations, in Earth Science, are spread throughout the presentations to provide students with multiple opportunities to practice manipulating and communicating information using the variables and units of measure associated with gradient, rate of change and eccentricity formulas.

**Location(s):**
Page 9, Slide 33
Earth’s History

I. Fossils – the remains of a _________________________________.

A. Fossil Formation – Fossilization

1. Fossils are incomplete only ____________________ of an organism will become fossilized.

2. Organisms become fossils __________ being __________ by several layers of ________________.

3. Most fossils are found in ____________________________ rock.
   a) __________________________ - rare; distorted or destroyed
   b) __________________________ - none, melt origin
4. _______________ occurs over time.

TIME

Sediments become

of hard parts by sediment.

expose fossil

B. Types of Fossils –

1. _______________ - empty space; takes the shape of the organism
2. _______________ - minerals fill in a mold left by an organism.

3. Imprints – (__________________________) when a living organism leaves an ____________________________, or any trace of biological activity, in soft ground/______, that later hardens into rock.

4. _______________/resin – insects or smaller organism get trapped and embedded in __________________________ that later __________________________ and becomes fossilized.

5. _______________ specimen - immediate preservation due to _______ storage.

   a) Can occur when ______________________ are trapped in ___________; tar will replace all organic material left behind.
   b) __________________________ - when minerals dissolved in ________________ gradually replace the original organic tissue.
7. ________________ film - ________________ stored in organic tissue
   leaves a thin ________________ of carbon which hardens and undergoes lithification.

C. Interpreting Fossils

1. Fossils indicate that -
   a) Many ________________ of life forms have existed at
      ________________ during Earth’s history.
   b) When arranged, according to ________________, the fossil record shows that certain
      living things have changed or ________________ over time.
   c) Earth’s surface has ________________

   Organisms Evolve Over Time

<p>| | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   d) Fossils give clues to Earth’s past ________________.
      (1) ________________ were the continents located and what ________________
          were on them.
   e) Fossils show the ________________ and ________________ of past life.

2. ____________________ - a fossil that is used to ________________ the rock
   ________________ in which it is found.
   a) An organism/species that ________________ during a relatively ________________
      well defined, ________________
   b) Has/had a ________________
II. Dating Rock Layers

A. _______________ dating -

1. Relative age - The age of something ___________________________ the age of something else.
   
   a) Using relative dating geologists can put rock columns into _______________.

2. Law/Principle of ___________________________ - in undisturbed sedimentary rock layers (___________), the ____________ rock is on the _____________.

3. ___________________________ rock layers and relative dating rules -
   
   a) A ____________ is _______________ than the rock layer it cuts across.
   
   b) The _______________________ and _______________________ of rock layers are events that are _______________ than the rock layers they affect.

   c) An igneous ______________________ is _______________ than the rock layers it moved through.
4. Law of __________________________ - a surface of __________________________
   between rock __________________________.
   
a) Represents a __________________________ in Earth's __________________________

   formation of horizontal layers

   Crustal __________________________
   and __________________________

   transported sediment

   Unconformity:
   Subsidence; sinking and __________________________ of horizontal strata.

5. __________________________ rock layers

   Correlation of Rock Columns

   Rock Formations

   Fossil Key: [Eurypterid, Brachiopod, Horn Coral, Trilobite]
B. 

1. ____________________ age - the ____________________ of how many years ago an event occurred or an organism lived; ____________________?

2. Radioactive ____________________

   a) ____________________ (parent) elements spontaneously ________

      into more ____________________ (daughter) elements by gaining or losing matter.

(1) ____________________ - the time it takes for one ________ of the ____________ element to decay into the ____________ element.

(a) Parent isotopes rate of decay (________________________) is ____________________ by environmental factors; such as ____________________, chemical reactions

(b) The rate of decay is ____________ and constant for individual parent isotopes
Radioactive Decay Data

<table>
<thead>
<tr>
<th>RADIOACTIVE ISOTOPE</th>
<th>DISINTEGRATION</th>
<th>HALF-LIFE (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-14</td>
<td>$^{14}_6C \rightarrow ^{14}_6N$</td>
<td>$5.7 \times 10^3$</td>
</tr>
<tr>
<td>Potassium-40</td>
<td>$^{40}_1K \rightarrow ^{40}_2Ca \rightarrow ^{40}_8Ar$</td>
<td>$1.3 \times 10^9$</td>
</tr>
<tr>
<td>Uranium-238</td>
<td>$^{238}_92U \rightarrow ^{206}_82Pb$</td>
<td>$4.5 \times 10^9$</td>
</tr>
<tr>
<td>Rubidium-87</td>
<td>$^{87}_37Rb \rightarrow ^{87}_57Sr$</td>
<td>$4.9 \times 10^{10}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parent Element</th>
<th>Daughter Element</th>
<th>Half-life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-14</td>
<td>Nitrogen-14</td>
<td>$5.7 \times 10^3$</td>
</tr>
<tr>
<td>Potassium-40</td>
<td>Argon-40</td>
<td>$1.3 \times 10^8$</td>
</tr>
<tr>
<td>Calcium-40</td>
<td></td>
<td>1,300,000,000</td>
</tr>
<tr>
<td>Uranium-238</td>
<td>Lead-206</td>
<td>$4.5 \times 10^9$</td>
</tr>
<tr>
<td>Stremium-87</td>
<td></td>
<td>49,000,000,000</td>
</tr>
</tbody>
</table>

b) Radioactive Decay Model -

Key: □ Parent/Radioactive isotope  ■ Daughter/Stable element

Half-life #:

1:0 1:1 1:2 1:3 1:4

Radioactive:Stable Ratio
A. The geologic time scale divides Earth's history into sections of time.

1. The sections include: Longest to shortest amount of time
   a) _____________: Precambrian, Phanerozoic
   b) _____________: Paleozoic, Mesozoic, Cenozoic
   c) _____________: Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Tertiary, Quaternary
   d) _____________: Early, Middle, Late;

   (1) Paleocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene, Holocene

   * _____________: pertains to __________________ or __________________ of animals.

   * Cene: ________________
2. The _______________ between geologic time intervals represent ________________________________ on Earth’s surface.

   a) Abundant life and ________________________________

   b) ________________________________ shifts.

   c) Major ________________________________

3. Geologic time began when Earth first formed about ________________________________

<table>
<thead>
<tr>
<th>Name of Era</th>
<th>MYA Million Years Ago</th>
<th>Duration (my)</th>
<th>Percent of Geologic Time Scale</th>
<th>Scale Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td></td>
<td></td>
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</tr>
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<tr>
<td>251</td>
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<tr>
<td>544</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4,600</td>
<td></td>
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</table>

Formation of Earth: 4,600 mya

Today: 0 mya
<table>
<thead>
<tr>
<th>ERA</th>
<th>PERIOD</th>
<th>LIFE</th>
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<tbody>
<tr>
<td></td>
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<td>Millions of Years Ago</td>
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<tr>
<td>Quaternary</td>
<td>1.6</td>
<td>abundant</td>
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<td></td>
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<td>Major Extinction</td>
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</tr>
<tr>
<td>Cretaceous</td>
<td>142</td>
<td>climax of Dinosaurs</td>
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<tr>
<td>Jurassic</td>
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<td>Dinosaurs</td>
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<tr>
<td></td>
<td></td>
<td>最早</td>
</tr>
<tr>
<td></td>
<td>206</td>
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<tr>
<td>Triassic</td>
<td></td>
<td>Mammals</td>
</tr>
<tr>
<td></td>
<td>251</td>
<td>Major Extinction</td>
</tr>
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<tr>
<td>Permian</td>
<td></td>
<td>first mammal-like</td>
</tr>
<tr>
<td></td>
<td>290</td>
<td>Reptiles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>最早</td>
</tr>
<tr>
<td></td>
<td>362</td>
<td>extensive coal-forming</td>
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<tr>
<td>Devonian</td>
<td>418</td>
<td>extinction of Armored Fish</td>
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<td></td>
<td>443</td>
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<td>Ordovician</td>
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<tr>
<td></td>
<td>544</td>
<td>Marine animals with shells</td>
</tr>
<tr>
<td></td>
<td>4600</td>
<td>Soft bodied organisms</td>
</tr>
</tbody>
</table>
Bedrock

- Major understandings:
  - Bedrock: the point at which soil/sediment stops and there is only rock.
    - Sediment will eventually turn into sedimentary rock with compaction pressure, and time.
  - Earth’s History lies within the stratigraphic columns; also known as the rock record.
    - Fossils and rock composition aid in the understanding of Earth’s past.
Igneous Intrusions

- Below the Earth’s hardened/cooled crust is the mantel; consists of molten/liquid rock (magma).
  - Magma transfers energy through convection currents; hot magma rises and cooler magma sinks.
  - Magma can rise through solid crust and become emplaced and cool into and igneous intrusion.
Crustal Deformation

- Earth’s crust moves due to the convection currents in the mantle; this movement may lead to crustal deformation.

- Faults

- Folding

- Tilting
Rock Symbols

- **Sedimentary Rocks:** Compaction and Cementation
  - Soft/weak rock; very susceptible to weathering and erosion.
    - Broken down and transported
  - Limestone: Calcite; shell fragments
  - Dolostone: Mineral precipitate: biologic origin
  - Conglomerate: Varying grain sizes; cementation ($H_2O$)
  - Sandstone: Sand grain sizes; compaction and cementation
  - Shale: Clay grain sizes; compaction
  - Siltstone: Silt size particles; compaction
Earth’s History
In what ways do scientists investigate the past?

- Describe what things scientists can discover and how that discovery tells them about the past?
  - What are some problems a scientist might face as they try to interpret the past?
  - Draw what you think of when you think of “Earth’s History.”
Fossils and the Past

I. Fossils are remains of a once living thing.
   1. Fossils are usually incomplete; only hard parts of an organism will become fossilized.
      ▪ Soft parts of an organism can be eaten or may decompose before burial takes place.
      ▪ Choose which organisms below could become fossils:

![Organisms for selection](image-url)
Fossil Formation

2. Organisms become fossils after being buried by several layers of sediment.
   - Sediment hardens and turns into rock, the dead organism becomes trapped in the rock.

3. Most fossils are found in sedimentary rock.
   - Metamorphic: rare; distortion or destruction.
   - Igneous: none, melt origin.
4. Fossilization

1. Living organism
2. Burial of hard parts by sediment
3. Sediments become rock
4. Uplift, weathering, erosion. Exposed Fossil
Types of Fossils

1. **Casts**: empty space; takes shape of organism
   - soft pieces decay; hard pieces are dissolved.

2. **Molds**: minerals fill in a mold left by an organism.
Types of Fossils

1. Imprints: (trace fossils) when a living organism leaves an impression in soft ground (mud); that later hardens to rock.

2. Amber/resin: insects or smaller organisms get trapped and embedded in tree sap that later hardens.
Types of Fossils

5. **Preserved** Specimen: immediate preservation due to **ice** storage.
Types of Fossils

6. Mineral **Replacement**:
   a) Can occur when *animals* are trapped in *tar*; tar will replace all organic material left behind.

   ![Image of fossilized animals and minerals]

   b) **Petrification**: when minerals dissolved in *water* gradually replace the original organic tissue.

   ![Image of petrified shells]
Types of Fossils

7. **Carbonaceous** film: When **carbon** stored in organic tissue leaves a thin **veneer** of carbon which hardens and turns to rock.
Interpreting Fossils

1. Fossils indicate that:
   a) Many **different kinds** of life forms have existed at **different times** during Earth’s history.

   b) When arranged, according to **age**, it shows that certain living things have changed or **evolved** over time.

   c) Earth’s surface has **changed over time**.
      - Fossils of marine organisms can be found on mountain tops; currently above sea level
Organisms Evolve Over Time
Interpreting Fossils

d) Fossils give clues to Earth’s past climates

1) **Where** were the continents located and what **features** were on them.
   - Since corals today live in the warm water, we can infer that N.Y.S. had a warmer climate in the past.

e) Fossils tell about the **appearance** and **activities** of past life.
   - Teeth tell type of food eaten.
2. Index Fossil

2. A fossil that is used to **date** the rock **layer** in which it is found.
   a) An organism that **lived** during a relatively **short**, well defined, **time span**
   b) Has/had a **wide geographic distribution**.
A. Relative Dating

1. Relative age: the age of something compared to the age of something else
   a) Using relative dating geologists can put rock columns into sequential order.

2. Law/Principle of Superposition - In undisturbed sedimentary rock layers (strata); the oldest rock is in the bottom
3. **Disturbed Rock Layers & Relative Dating**

   a) A **fault** is **younger** than the rock layers it cuts across.

   b) The **folding** and **tilting** of rock layers are events that are **younger** than the rock layers they effect.

   c) An igneous **intrusion** is **younger** than the rock layers it penetrates.
4. **Law of Unconformity - A surface of erosion between rocks layers**

a) Represents a **missing gap** in Earth’s history.

- **Deposition**: formation of horizontal layers
- **Crustal Uplift and Folding**
- **Erosion**: transported sediment
- **Unconformity**: Subsidence; sinking **Deposition** of horizontal strata
Determining Relative Age
Correlation of Rock Columns

Column A
- Green Shale
- Tan Limestone
- Red Sandstone
- Grey Siltstone
- Brown Sandstone
- Black Shale
- Grey Limestone

Column B
- Brown Siltstone
- Conglomerate
- Green Shale
- Tan Limestone
- Red Sandstone
- Grey Siltstone
- Brown Sandstone

Column C
- Mastodont remains
- Glacial Till
- Brown Siltstone
- Conglomerate
- Green Shale
- Grey Sandstone
- Tan Limestone

Rock Formations

Fossil Key:
- Eurypterid
- Brachiopod
- Horn Coral
- Trilobite
B. Radioactive Dating

1. Absolute age - The measure of how many years ago an event occurred or an organism lived; how old is it?

2. Radioactive Decay –
   a) Radioactive (parent) elements spontaneously change into more stable (daughter) elements by gaining or losing matter.
Radioactive or parent element is unstable and will spontaneously loss or gain matter to become stable.

Decayed or daughter element is the stable element that results after radioactive decay takes place.

Choose a type of decay and create a mind map as you learn more about it.
Radioactive Decay

1) **Half-life** - the time it takes for one **half** of the **parent** element to decay into the **daughter** element
   
a) Rate of decay (**half-life**) is **not affected** by environmental factors:

   - **Heat**
   - **Pressure**
   - **Chemical reactions**

b) The rate of decay is **unique** and **constant** for individual radioactive elements; see pg. 1 in ESRT’s.
Half-life

- Carbon-14 has a relatively short half-life and is an essential element for life.
  - Often used to date the remains of ancient living things such as; wood bones and leather.

<table>
<thead>
<tr>
<th>RADIOACTIVE ISOTOPE</th>
<th>DISINTEGRATION</th>
<th>HALF-LIFE (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-14 C&lt;sup&gt;14&lt;/sup&gt;</td>
<td>C&lt;sup&gt;14&lt;/sup&gt; → N&lt;sup&gt;14&lt;/sup&gt;</td>
<td>5.7 x 10&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Potassium-40 K&lt;sup&gt;40&lt;/sup&gt;</td>
<td>K&lt;sup&gt;40&lt;/sup&gt; → Ar&lt;sup&gt;40&lt;/sup&gt; Ca&lt;sup&gt;40&lt;/sup&gt;</td>
<td>1.3 x 10&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>Uranium-238 U&lt;sup&gt;238&lt;/sup&gt;</td>
<td>U&lt;sup&gt;238&lt;/sup&gt; → Pb&lt;sup&gt;206&lt;/sup&gt;</td>
<td>4.5 x 10&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rubidium-87 Rb&lt;sup&gt;87&lt;/sup&gt;</td>
<td>Rb&lt;sup&gt;87&lt;/sup&gt; → Sr&lt;sup&gt;87&lt;/sup&gt;</td>
<td>4.9 x 10&lt;sup&gt;10&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parent Element</th>
<th>Daughter Element</th>
<th>Half-life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-14 C&lt;sup&gt;14&lt;/sup&gt;</td>
<td>Nitrogen-14 N&lt;sup&gt;14&lt;/sup&gt;</td>
<td>5.7 x 10&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Potassium-40 K&lt;sup&gt;40&lt;/sup&gt;</td>
<td>Argon-40 Ar&lt;sup&gt;40&lt;/sup&gt; Calcium-40 Ca&lt;sup&gt;40&lt;/sup&gt;</td>
<td>1.3 x 10&lt;sup&gt;9&lt;/sup&gt; 1,300,000,000</td>
</tr>
<tr>
<td>Uranium-238 U&lt;sup&gt;238&lt;/sup&gt;</td>
<td>Lead-206 Pb&lt;sup&gt;206&lt;/sup&gt;</td>
<td>4.5 x 10&lt;sup&gt;9&lt;/sup&gt; 4,500,000,000</td>
</tr>
<tr>
<td>Rubidium-87 Rb&lt;sup&gt;87&lt;/sup&gt;</td>
<td>Strontium-87 Sr&lt;sup&gt;87&lt;/sup&gt;</td>
<td>4.9 x 10&lt;sup&gt;10&lt;/sup&gt; 49,000,000,000</td>
</tr>
</tbody>
</table>
Radioactive Decay Model

Key:  - Parent/Radioactive isotope  - Daughter/Stable element

Half-life #: 0 1 2 3 4

Radioactive: Stable Ratio

1:0 1:1 1:3 1:7 1:15

5,700γ 11,400γ 17,100γ 22,800γ

1/2 1/4 1/8 1/16 15/16
Geologic Time – Pg. 8&9 of ESRT’s
A. The geologic time scale **divides** Earth’s history into sections of time.

1. The sections include:
   
   a) **Eon(s)**: *Precambrian* (*Archean/Protozoic*), Phanerozoic
   
   b) **Era(s)**: Paleozoic, *Mesozoic*, *Cenozoic*
   
   c) **Period(s)**: Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, *Triassic*, *Jurassic*, *Cretaceous*, *Tertiary*, *Quaternary*
   
   d) **Epoch(s)**: Early, Middle, Late; Paleocene, Eocene, *Oligocene*, *Miocene*, *Pliocene*, Pleistocene, Holocene

   - **-Zoic**: pertains to *animals* or *activities* of animals
   - **-Cene**: Recent
Geologic Time

2. The **boundaries** between geologic time intervals represent **major changes** on Earth’s surface which include:
   a) Abundant life and **Major Extinctions**
   b) **Global Climate** Shifts
   c) Major **Geologic Events**

3. Geologic Time began when Earth first formed about **4.6 bya** (billion years ago.)
# Model of Geologic Time Scale

<table>
<thead>
<tr>
<th>Name of Era</th>
<th>MYA (Millions of Years Ago)</th>
<th>Duration (mya)</th>
<th>Percent of Geologic Time Scale</th>
<th>Scale Model 25cm=100%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cenozoic</strong></td>
<td>0</td>
<td>65</td>
<td>$\frac{65}{4600} \times 100 = 1.4%$</td>
<td>.35 cm</td>
</tr>
<tr>
<td><strong>Mesozoic</strong></td>
<td>65</td>
<td>186</td>
<td>$\frac{186}{4600} \times 100 = 4.0%$</td>
<td>1 cm</td>
</tr>
<tr>
<td><strong>Paleozoic</strong></td>
<td>251</td>
<td>293</td>
<td>$\frac{293}{4600} \times 100 = 6.4%$</td>
<td>1.6 cm</td>
</tr>
<tr>
<td><strong>Precambrian</strong></td>
<td>544</td>
<td>4056</td>
<td>$\frac{4056}{4600} \times 100 = 88.2%$</td>
<td>22.1 cm</td>
</tr>
<tr>
<td>Era</td>
<td>Period</td>
<td>Millions of Years Ago</td>
<td>Life</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>-----------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Precambrian</td>
<td>4600</td>
<td></td>
<td>Soft bodied</td>
<td></td>
</tr>
<tr>
<td>Cambrian</td>
<td>490</td>
<td></td>
<td>Fish, Trilobites, Marine animals with shells, Invertebrates</td>
<td></td>
</tr>
<tr>
<td>Ordovician</td>
<td>443</td>
<td></td>
<td>Fish, Insects, Land Plants</td>
<td></td>
</tr>
<tr>
<td>Silurian</td>
<td>418</td>
<td></td>
<td>Trilobite, peak development of Eurypterids</td>
<td></td>
</tr>
<tr>
<td>Devonian</td>
<td>290</td>
<td></td>
<td>Reptiles, Forests</td>
<td></td>
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<tr>
<td>Permian</td>
<td>251</td>
<td></td>
<td>First mammal-like</td>
<td></td>
</tr>
<tr>
<td>Triassic</td>
<td>142</td>
<td></td>
<td>Mammals, major extinction</td>
<td></td>
</tr>
<tr>
<td>Cretaceous</td>
<td>65</td>
<td></td>
<td>Dinosaur, flowering plants</td>
<td></td>
</tr>
<tr>
<td>Tertiary</td>
<td>1.6</td>
<td></td>
<td>Abundant, climax of</td>
<td></td>
</tr>
<tr>
<td>Quaternary</td>
<td>earliest</td>
<td></td>
<td>Humans, Mammals</td>
<td></td>
</tr>
</tbody>
</table>

- ~50% of life
- ~90% of life
Observations of Human Change Over Time

- As you view the next few slides:
  - Record and describe your observations and thoughts.

- After observations:
  - Connect ideas and develop a picture to express your understanding with your peers
Early Hominids

Australopithicus

Neanderthal

Cro-Magnon

Homosapien
Change Over Time
Early Man’s Tools
### Climate & Meteorology

<table>
<thead>
<tr>
<th><strong>Strategy:</strong></th>
<th>Activating Cognitive Schema</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Descriptive, pictorial</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>As students explore what they know about a new topic and how they may identify with it, they are required to activate the schema necessary to continue learning about the topic at hand. This strategy creates a pathway for deeper understanding and learning, as ideas are scaffolded throughout the notes. By activating prior knowledge and communicating that knowledge in several different ways students learn to reflect on their understanding of the topic before it is introduced.</td>
</tr>
</tbody>
</table>
| **Location(s):** | Page 1, Slide 2  
Page 7, Slide 25 |
| **Reference:** | Think Trix; Kagan (2005)  
Thinking Questions (1999) |

<table>
<thead>
<tr>
<th><strong>Strategy:</strong></th>
<th>Summative Cognitive Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Descriptive, textual, pictorial</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>Throughout the note-packets students are asked to copy and create several drawings. Summative descriptive strategies provide students with the opportunity to combine the main ideas and drawings from within the lecture; into a cohesive statement of understanding. Through this process students and teachers can monitor how students make connections between new ideas and previous knowledge. These strategies provide insight into student comprehension and perception of segmented and holistic scientific systems and processes.</td>
</tr>
</tbody>
</table>
| **Location(s):** | Page 6, Slide 24  
Page 32, Slide 108 |
| **Reference:** | Thompson & Thomason (1999) |
**Strategy:** Summative Cognitive Reflection

**Modes of Communication:** Depictive, symbolic, textual

**Rational:** Units within the Earth Science curriculum introduce students to major ideas about the physical world around us with tremendous amounts of detail. Students must understand these details to properly communicate the broader ideas within a unit. Summative depictive strategies provide students with the opportunity to work through and review the textual information within their notes. As they review these new ideas and relationships students illustrate their thinking processes through graphic organizers or mind mapping tasks. These strategies allow teachers and students to visualize connections that students are making with new information and promote discussion and assessment of internal comprehension.

**Location(s):**
- Page 4, Slide 16
- Page 13, Slide 46
- Page 22, Slide 77
- Page 24, Slide 86
- Page 29, Slide 101
- Page 36, Slide 118

**Reference:**
- Thinking Questions; Kagan (1999)

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**Strategy:** Visual Representation

**Modes of Communication:** Descriptive, pictorial, iconic

**Rational:** Visual representations are meant to provide students with an illustration of an idea or word without demanding more from their working memory. Visual-descriptive strategies allow students to illustrate properties of an idea, rather than focus on the textual information. Student perceptions of the concept and its properties are prominent in this strategy. Teachers should allow students opportunities to revise or add to images created during note taking.

**Location(s):**
- Page 9, Slide 33
- Page 10, Slide 37
- Page 26, Slide 92
- Page 26, Slide 93
- Page 31, Slide 106
**Strategy:** Visual Interpretation

**Modes of Communication:** Depictive, pictorial, symbolic

**Rational:** Focusing on the textual information provided within the notes students create mental and physical images. The visual-depictive strategy will aid in the creation of mental models as note taking occurs. In each instance the student is asked to interpret the text and create an illustration that depicts their understanding. This creates an internal connection between the student and the concept, as well as supporting informal assessment techniques.

**Location(s):**

<table>
<thead>
<tr>
<th>Page, Slide</th>
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<td>3, 11</td>
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<td>3, 12</td>
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<td>5, 20</td>
<td>16, 59</td>
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<td>8, 29</td>
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<td>9, 34</td>
<td>22, 75, 76</td>
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<tr>
<td>10, 35, 36</td>
<td>24, 84</td>
<td></td>
</tr>
</tbody>
</table>

**Strategy:** Graphic Interpretation

**Modes of Communication:** Descriptive, pictorial

**Rational:** Throughout the Earth Science curriculum and within the NYS Regents exams students are expected to interpret information from and add information to a multitude of diagrams. Within the graphic-descriptive strategy students are asked to analyze diagrams for information and add or pull information from the diagrams based on information provided within the unit. The use of this strategy affords teachers with the opportunity to nurture the use of diagrams, and provides students with a basis for the utilization of diagrams in science.

**Location(s):**

<table>
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<th>Page, Slide</th>
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<td>18, 66, 67</td>
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<td>20, 71, 72</td>
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<td>23, 80</td>
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<td>28, 99</td>
<td></td>
</tr>
<tr>
<td>33, 111</td>
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</tr>
</tbody>
</table>
**Strategy:** Mathematical Representation

**Modes of Communication:** Depictive, pictorial, symbolic

**Rational:** Mathematical-symbolic strategies focus on the development of simple graphic images to represent the relationships between two or more variables. The development of each instance varies from linear to axial locations and labels. Each variation was chosen to draw the attention to the specific variables and how each behaves in relation to one another. Students and teachers should engage in scientific discourse as the relationships are identified and represented.

**Location(s):**
Page 2, Slide 6  
Page 2, Slide 7  
Page 2, Slide 9  
Page 12, Slide 42  
Page 16, Slide 55, 56, 57  
Page 23, Slide 82

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**Strategy:** Mathematical Interpretation

**Modes of Communication:** Symbolic, textual

**Rational:** Several equations are used throughout the curriculum to aid in student understanding of illustrated or observed data. These common place equations, in Earth Science, are spread throughout the presentations to provide students with multiple opportunities to practice manipulating and communicating information using the variables and units of measure associated with gradient, rate of change and eccentricity formulas.

**Location(s):**
Page 15, Slide 54  
Page 27, Slide 96  
Page 33, Slide 112
Climate & Meteorology

I. Climate – The weather conditions, including temperature, precipitation and wind that characteristically occur in a particular region.

- An area’s

A. Factors that affect climate –

1. 
2. 
3. 
4. Marine vs. 
5. Effect

1. Latitude and Insolation

a) Higher latitudes have temperatures, because they receive less direct .

   (1) Insolation –
       (a) Short daylight periods, shadow.
       (b) Long daylight periods, shadows.
b) _______________ yearly temperatures (_______)

(1) Mathematical average of temperature measurements taken every
day for one year.

(2) As _______________ _______________, _______________

_______________

c) Yearly Temperature _______________ (YTR)

(1) _______________ and _______________

temperatures for a particular area during a _______ period.

(2) As _______________ _______________,

_______________

2. Altitude - _______________ especially _______________
or above the Earth’s surface.

a) As _______________ _______________,

_______________
3. ◯ _______________ - make the climate of ________________________ regions warmer or cooler __________________________ for that latitude.

◯ Pg ______ of ESRT's

Warmer or Colder Than Normal?

East Coast of N.A. ____________

East Coast of S.A. ____________

4. Marine vs. Continental -

a) __________________________ and loses heat much ____________ than water.

(1) Land areas tend to have:

(a) __________________________ and __________________________.

(b) Continental climates have __________________________

__________

(2) ____________ ; near large bodies of water tend to have:

(a) __________________________ and __________________________.

(b) Marine climates have ________________.
5. **Orographic Effect and Rain Shadow Effect**

   a) **Caused by mountain ranges or coastal areas of higher elevation.**

   (1) **Orographic Effect - ___________ side.**

      (a) ___________ and ___________ temperatures

      (i) ___________, Hawaii, Amazon Valley

   (2) **Rain Shadow Effect - ___________ side**

      (a) ___________ and ___________ temperatures

      (i) ___________, deserts of Peru
B. Factors that Affect Rainfall –

1. **Latitude** - ________________ produces global ________
   and air______________ belts.
   a) **Low pressure belts produce** __________ regions.
   b) **High pressure belts produce** __________ regions.

   ![Planetary Wind and Moisture Belts in the Troposphere](image)

   The drawing on the right shows the locations of the belts near the time of an equinox. The locations shift somewhat with the changing latitude of the Sun’s vertical ray. In the Northern Hemisphere, the belts shift northward in the summer and southward in the winter.

   (Not drawn to scale)

   (1) **Wet latitudes are:** __________________________

   (2) **Dry latitudes are:** __________________________

2. **Areas of Rainfall –**

   a) **Regions on Earth where air** ________________

      ________________ forms clouds and precipitates.

   (1) ________________ side of a mountain

   (2) ________________ ________________ regions

   *Where warm humid air rises as a result of_________________.

   (a) Produces thunderstorms almost ________________.
b) **Regions on Earth where prevailing** ____________ blow in ________

____________________________ ; usually receive more rainfall.

3. Areas of _________ rainfall -
   
a) **Regions on Earth where air** ____________________________

_________________________ and becomes less humid/__________.

(1) ________________________ side of mountain

(2) **Horse (mid) latitudes** - ______________________

(3) **High pressure weather systems**

b) **Regions on Earth where** ________________________ winds blow from

the interior of a ______________________ ; usually receive less

rainfall.

C. Region/Climate Comparison

1. Death Valley, California - ______________

2. Cherrapunji, India - ______________

3. Amazon Valley, South America - ______________

4. Deserts of Peru, South America - ______________
Meteorology: The scientific study of the atmosphere that focuses on_________________________ 
_________________________ for a location at_________________________

II. Weather – The state, or_________________________, of atmospheric 
_________________________ for a location at_________________________

A. Atmospheric Variables & Measurements:
1. ___________________ \(\rightarrow\) _____________________
2. ___________________ \(\rightarrow\) _____________________
3. ___________________ \(\rightarrow\) _____________________
4. ___________________ \(\rightarrow\) _____________________ or inches of Mercury

B. Causes of Weather:
1. Amount of_________________________ (Incoming SOLar radiation.)

   a) __________

   b) __________
2. ________________________________ of Earth’s surface.

   a) **Surface heating is dependent on** ________________________________ of sunlight.

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<thead>
<tr>
<th>Low Latitude</th>
<th>Mid Latitude</th>
<th>High Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image of Low Latitude" /></td>
<td><img src="image2" alt="Image of Mid Latitude" /></td>
<td><img src="image3" alt="Image of High Latitude" /></td>
</tr>
</tbody>
</table>

   b) **The uneven heating of Earth’s surface causes the** ________________________________ to react and ________________________________ and infinite variety of weather ________________________________

C. **Weather Instruments:**

- **Measures Air** ________________________________
  - Sling Psychrometer
  - Wet Bulb
  - Dry Bulb
  - Measures
  - Relative
  - &

- **Measures** ________________________________

- **Measures** ________________________________

- **Measures** ________________________________
III. Atmosphere - The shell of air (______________) that surrounds the Earth.

A. Molecular Composition of the Atmosphere
   1. 78% - __________
   2. 21% - __________
   3. 0-4% - __________
   4. 0.93% - Argon
   5. .03% - __________
   6. .01% - __________ gases; ex. __________
   7. Dust particles (______________________________)

B. Composition vs. Altitude:
   1. 50 miles - From Earth’s surface to the Stratopause there is a mixture of gases including ____________________________.
   2. 600 miles - between the Mesosphere and the Ionosphere there is a layer of Oxygen and then a layer of Helium.
   3. ________ miles - At the top of the Ionosphere there is a layer of Hydrogen that thins out into space.

C. Temperature vs. Altitude: page _____ of ESRT.
D. The Atmosphere & Insolation: Our Heat Budget

1. 6% - Reflected by _____________, dust particles and water droplets
2. 20% - _________________ by clouds.
3. 4% - Reflected by _________________.
4. 3% - Absorbed by _________________.
5. 51% - Absorbed by _________________.
6. 16% - Absorbed by _____________, water vapor and dust

---

100 Units of Insolation

Surface of Earth

Re-radiation from Earth’s surface
IV. Temperature & Heat

A. Heat Transfer – how heat moves.

1. Conduction – Heat is transferred through the ____________
   
a) This occurs best in ____________, where molecules are closely packed.
   
   Molecules vibrate ________ when heat is applied.

2. ____________ – Heat is transferred through the movement of ________ & ________.
   
a) As ______ water rises it mixes with _____ water and creates an up and down pattern; called convection currents.

3. Radiation – Heat is transferred by __________________________ through air or space.
   
a) ________________, __________________________ and other electromagnetic waves travel through a vacuum from the Sun to the Earth daily.

Ex: __________________________
B. Factors that Affect the Amount/Rate of Heating

1. The _______________ and _______________ of sunlight.
   
   a) _______________/time of day

   (1) The angle of _____________________________________________ in
   the course of one day/seasons; __________________ intensity
   occurs at __________/summer.

2. Specific Heat - The ______________________________ per unit mass required
   ______________________________ by one degree Celsius.

1. page ______ ESRT's

   Specific Heats of Common Materials

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>SPECIFIC HEAT (Joules/gram °C)</th>
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<tbody>
<tr>
<td>Liquid water</td>
<td>4.18</td>
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<tr>
<td>Solid water (ice)</td>
<td>2.11</td>
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<tr>
<td>Water vapor</td>
<td>2.00</td>
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<tr>
<td>Dry air</td>
<td>1.01</td>
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<tr>
<td>Basalt</td>
<td>0.84</td>
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<td>Granite</td>
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<td>Iron</td>
<td>0.45</td>
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<td>Copper</td>
<td>0.38</td>
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<tr>
<td>Lead</td>
<td>0.13</td>
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</tbody>
</table>

3. ______________ vs. ______________
   
   a) ___________ heats up and cools down ___________ than water.

4. Color: ______________________________
   
   a) ___________ colors heat up _______________ than lighter colors.

5. Texture: ______________ vs. ______________
   
   a) ___________ surfaces heat up _______________ than smooth surfaces
      because rough surfaces have more surface area.
C. Measuring Temperature – page _____ of ESRT

![Temperature Conversion Chart]

- 312°F = Water __________
- 99°F = Body Temp
- 68°F = Room Temp
- 32°F = Water Freezes

- 195°F = Dry Ice
- 77°F = Air Freezes
- 273°C = Absolute Zero

-109°C = Dry Ice
-320°C = Air Freezes
-460°C = Absolute Zero

<table>
<thead>
<tr>
<th>Fahrenheit</th>
<th>Celsius</th>
<th>Kelvin</th>
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</thead>
<tbody>
<tr>
<td>700</td>
<td>370</td>
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<td>-30</td>
<td>-50</td>
<td>180</td>
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<tr>
<td>-40</td>
<td>-60</td>
<td>150</td>
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</tbody>
</table>
V. Moisture – dampness that can be felt as vapor (gas) in the atmosphere or condensed liquid on the surfaces of objects.

A. The Water Cycle
1. The primary source of ______________ for the water cycle is the sun.
2. Transpiration is the process by which ______________ release ______________ into the atmosphere.
3. ______________ is falling liquid or solid water from the clouds to the Earth’s surface.
   a) Ex: ______________

B. Changes in States of Matter – page _____ of ESRT

1. States of Matter
   a) ______________
   b) ______________
   c) ______________

<table>
<thead>
<tr>
<th>Properties of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat energy gained during melting ............ 334 J/g</td>
</tr>
<tr>
<td>Heat energy released during freezing ............ 334 J/g</td>
</tr>
<tr>
<td>Heat energy gained during vaporization ....... 2250 J/g</td>
</tr>
<tr>
<td>Heat energy released during condensation ...... 2250 J/g</td>
</tr>
<tr>
<td>Density at 3.98°C ......................... 1.0 g/mL</td>
</tr>
</tbody>
</table>
2. Phases of Matter – how they ____________
   a) Evaporation ←→ ____________
   b) ____________ ←→ Freezing
   c) ____________ ←→ Deposition

*Each of these paired phase changes occurs at the ________ temperature, depending on the material.

3. ____________ ←→ ____________
   a) ____________: occurs as a solid turns into a liquid; by warming.
      (1) Water must ________ 334 calories of ________/heat
          to change 1g of ice into liquid water.
   b) ____________: occurs as a liquid turns into a solid; by cooling.
      (1) Water molecules ____________ the same amount of
          ____________ that is gained during melting.

4. ____________ ←→ ____________
   a) ____________: occurs as a liquid changes into a ________
      (1) Water must ________ 2260 calories of energy to change 1g of
          liquid water into water vapor.
   b) ____________: occurs as a gas changes into a liquid
      (1) Water molecules ____________ the same amount of energy
          that is gained during evaporation.
      (2) Condensation in the atmosphere results in the formation of
          ____________ and ____________.
5. Factors Affecting the Rate of Vaporization (Evaporation)

- **Temperature:** As temperature increases, the rate of vaporization increases.
- **Humidity:** As humidity increases, the rate of vaporization decreases.
- **Wind:** As wind increases, the rate of vaporization increases.
- **Surface Area:** As surface area increases, the rate of vaporization increases.
- **Specific Heat:** As specific heat increases, the rate of vaporization decreases.

6. **Phase Changes**

- **(1) Solidification:** occurs as a solid changes directly into a gas. 
  
  - **Ex:** Mothballs and ____________

- **Sublimation:** occurs as a gas changes directly into a solid.
C. Moisture in the Atmosphere - the primary source for water in the atmosphere is the oceans. Other sources include ____________________________

1. Water exists as all three states in the atmosphere:
   a) Solid-minute _______________ suspended in the air
   b) Liquid-minute water _______________ suspended in the air
   c) Gas- _______________

2. ________________ is the general term used to describe the ________________ of water ________________ in the air.

3. ________________ determines the amount of water vapor the air can ________________.
   a) As air temperature ________________, the amount of water vapor the air can hold also increases.

4. ________________ occurs when air holds ________________ water vapor ________________ at a given ________________.
   a) Rate of ________________ = Rate of ________________

---

A  
B  
C  

Unsaturated  
Unsaturated  
Saturated

- air molecule  
- water molecule  
- Evaporation  
- Condensation
5. **Dew Point Temperature** - the temperature to which ________________
______________ to reach saturation.

a) **Measuring with a** ________________

(1) Two thermometers; one ______ bulb and one ______ bulb.

(2) When whirled in the air evaporation occurs on the ______
bulb. This causes the temperature of the wet bulb to ________.

(3) ________________ between the dry bulb and the wet bulb
______________ the ________________ and the
relative humidity of the air.

(a) The air is saturated when the difference between the two
bulbs equals ________.

(i) Dry air: greater difference between wet and dry
bulbs. More ________________ and cooling.

(ii) Humid air: smaller difference between the wet
and dry bulb. ______ evaporation and cooling.

b) **Measuring Dew Point**: Use page _____ in your ESRT’s to complete the
following table.

```
<table>
<thead>
<tr>
<th>Dewpoint (°C)</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
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<th>21</th>
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<tbody>
<tr>
<td>Dry Bulb (°C)</td>
<td>22</td>
<td>22</td>
<td>20</td>
<td>15</td>
<td>9</td>
<td>8</td>
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<table>
<thead>
<tr>
<th>Dry Bulb Temp</th>
<th>22°C</th>
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<tbody>
<tr>
<td>Wet Bulb Temp</td>
<td>20°C</td>
<td>13°C</td>
<td>14°C</td>
<td>12°C</td>
<td>3°C</td>
<td>6°C</td>
<td>17°C</td>
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</table>

Difference

Dew Point
6. The ratio between the amount of water in the air to the amount of water vapor the air can at any given temperature.

**Factors that affect Relative Humidity:**

1) If the temperature remains the same, relative humidity will.

2) Time of day
   a) RH occurs around 5 am when it’s the
      b) RH occurs around 3 pm when air temperature is the

b) Absolute Humidity: the amount of water vapor in the air.

1) If in the air increases and remains the same, relative humidity will.
c) Measuring Relative Humidity: Use page _____ of the ESRT to complete the following chart.

<table>
<thead>
<tr>
<th>Relative Humidity (%)</th>
<th>Difference Between Wet-Bulb and Dry-Bulb Temperatures (°C)</th>
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</table>

Dry Bulb Temp | 20°C | 8°C | 22°C | 22°C | 15°C | 15°C | 3°C |
Wet Bulb Temp | 14°C | 6°C | 13°C | 20°C | 12°C | 15°C | 1°C |

7. Clouds – tiny droplets of __________ water or minute __________ crystals suspended in the air.

a) Conditions needed for Cloud formation

   (1) __________ in the air.

   (2) __________ temperatures

   (3) Condensation __________

   (a) Aerosols in the atmosphere; which provide a surface for liquid water/ice to condense upon.

b) Precipitation __________
c) **Adiabatic Cooling:** cooling in the atmosphere

1. As a parcel of ____________________, the amount of air _______________ surrounding the parcel _______________.

2. The parcel will begin to _______________ in volume as it rises. As it expands, it becomes _______________.

3. When its temperature _______________ to its _______________ temperature, the water _______________ in the air _______________ and cloud forms in the sky.

d) **Cloud Types**

1. _______________: wispy and light.

2. _______________: Spread out or layered.

3. _______________: Heaps or piles, vertical growth.

4. _______________: Prefix meaning “high”

5. _______________: Rain-bearing or snow-bearing
e) Using the descriptions draw and label different cloud types below:
VI. Air Pressure – The force of ____________ causes the air to have ____________; this creates air pressure.

A. Air pressure acts ________________ in all directions
   1. All objects that contain air have ________________
      a) Ex: ________________________________

B. Measuring air pressure:
   1. Air pressure at sea level is ______ pounds per square inch.
   2. Standard atmospheric pressure at _______________ is:
      a) ________________________________
      b) ________________________________
      c) ________________________________

   3. Use page _____ in ESRT’s to convert millibars into inches of Mercury.
      a) 997 mb = _______ in
      b) _______ = 30.15 in
      c) 982 mb = _______ in
      d) _______ = 29.53 in

C. Factors that cause a change in air pressure:
   1. Temperature as ______ temperature ______________ molecules
      move ______________; and the air becomes less ______________.
      air pressure ______________.
2. Moisture- as _______________ of the air _______________ air pressure _______________.
   
   a) Moist/_____________ air holds more water ___________ molecules.
   
   b) Water vapor molecules are ___________ then the ___________ dry air molecules they replace.

   c) Water vapor molecules replace dry air molecules during ___________.

3. Altitude – as altitude _______________, air pressure _______________.
   
   a) At ___________ altitudes there is less air above you and the air is less ___________.

   ![Pressure vs Altitude Graph]
VII. Wind – The ________________ movement of air; ________________ to Earth’s surface.

A. Causes of Wind –

1. ________________ heating of Earth’s surface.
   
a) Land vs. ________________

   b) ________________ vs. Equator

   c) Dark forest vs. ________________

2. Winds help distribute ________________ from regions with ________________ energy to regions with ________________ energy.

B. Sea-Breeze vs. Land-Breeze

1. Sea-Breeze:
   
a) Land air is warmer and ________________; ______________ pressure

   b) Air over Lake Ontario is cooler and ________________; ______________ pressure.

   ![Diagram of high-pressure H and low-pressure L near land and lake]

2. Land-Breeze:
   
a) Land air is cooler and more ________________; ______________ pressure.

   b) Air over Lake Ontario is warmer and ________________ dense; ______________ pressure.

   ![Diagram of low-pressure L and high-pressure H near land and lake]
C. Wind Direction – Winds always blow from regions of ______ pressure to regions of ______ pressure.

1. The Coriolis Effect:
   a) The Earth’s ______ on its axis causes winds to be deflected.
      (1) Northern Hemisphere – to the ______ (___________)
      (2) Southern Hemisphere – to the ______ (___________)

   b) Global Winds – cause by unequal distribution of insolation.

2. Cyclones vs. Anticyclones:
   a) Anticyclones – ______ pressure systems
      (1) Winds move in a ______, ______ spiral.

   b) Cyclones – ______ pressure system
      (1) Winds move in a ______, ______ spiral.
c) Side view of cyclone and anticyclone

D. Wind Speed – the speed of the wind is determined by the difference in
_________________________ between two locations.

1. Pressure __________________: The difference in air pressure at two
separate locations.
   a) As the air pressure gradient ___________________, wind speed
      ____________________.

2. Wind speed is measured in ____________________.
   a) _______ knot = _______ ___ / _____

Determining Pressure Gradient: ESRT

1. Where is the pressure gradient the
greatest? ______________

2. Where is the wind speed the slowest?
   __________________

3. What is the pressure gradient between
   Niagara Falls and Rochester?
   __________________

   Page _____ of ESRT's

   Gradient = change in field value
             distance
VIII. **Air Mass** - A large body of ______ in the __________ with similar characteristics. Ex: ________________________________

A. **Source Region** - a geographic region where air mass was ________________
   1. Picks up ________________________________________ that it formed over.

B. **Types of Air Masses** –
   1. Tropical - originates over __________ regions.
      a) __________ temperatures
   2. Polar - originates over __________ regions.
      a) __________ temperatures
   3. Arctic - originates over __________ regions.
      a) Very __________ and ________ / arid.
   4. Equatorial - originates over __________ regions.
      a) Very __________ and ________ / moist.
   5. Continental - originates over ____________________________
      a) __________
   6. Maritime - originates over ____________________________
      a) ________ / humid.

C. __________________________ are a combination of __________________________
   and __________________________ conditions from their source region.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Source Region</th>
<th>Name of Air Mass</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>mT</td>
<td>Continental Polar</td>
<td>Cold &amp; Dry</td>
<td></td>
</tr>
<tr>
<td>cA</td>
<td>Continental Tropical</td>
<td>Warm &amp; Moist</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maritime Polar</td>
<td>Very Cold &amp; Very Dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cold &amp; Moist</td>
<td></td>
</tr>
</tbody>
</table>
D. USA – Source Regions
IX. **Weather Fronts** - a ______________ between ____________________.

A. Cold front - the front edge of a cold air mass ________________ and ________________ warmer air.
   
   1. Narrow band of ________________ usually comes before a cold front moves in.

B. Warm-front - the front edge of a warm air mass ________________ and ________________ colder air.
   
   1. A wide band of ________________ usually comes just before a warm front moves in.

C. Stationary front - ______ different air masses move _____________ to each other and Earth's surface.

D. Occluded Front - two or ______ air masses interact and combine at their ________________.
E. Page _______ of ESRT’s

Key to Weather Map Symbols

Station Model Explanation

Station Model

<table>
<thead>
<tr>
<th>Present weather</th>
<th>Amount of cloud cover (approximately 75% covered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°F)</td>
<td>196 Barometric pressure (1019.6 mb)</td>
</tr>
<tr>
<td>Visibility (mi)</td>
<td>+19/ Barometric trend (a steady 1.5 mb rise in past 3 hours)</td>
</tr>
<tr>
<td>Dewpoint (°F)</td>
<td>.25 Precipitation (0.25 inches in past 6 hours)</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Wind direction (from the southwest)</td>
</tr>
<tr>
<td>Whole feather = 10 knots half feather = 5 knots total = 15 knots</td>
<td></td>
</tr>
</tbody>
</table>

Today’s Weather

Drizzle
Rain
Smog
Hail
Thunderstorms
Rain showers
Snow
Sleet
Freezing rain
Fog
Haze
Snow showers

Air Masses

- continental arctic
- continental polar
- continental tropical
- maritime tropical
- maritime polar

Fronts

- Cold
- Warm
- Stationary
- Occluded

Hurricane

Tornado

---

31
X. Weather Maps:

A. Isoline –
   1. A line connecting points of _______________ on a map.
      
      a) Isolines illustrate weather __________ on a map field.

B. Isotherm –
   1. Lines that connect points of equal __________
      
      a) Points of equal value connect __________ across the US.

C. Isobars –
   1. Lines that connect points of equal __________
      
      a) Points of equal value connect in __________ on a map.
D. Mapping a temperature field –

1. Connect points of equal temperatures in intervals of 10°F
   
   a) (... 30, 40, 50, 60, 70, 80...)

2. The greatest temperature gradient is between ________________ and ________________.
   
   a) This is indicated by the isotherms being ____________________

3. Calculate the temperature gradient from Cincinnati to Chicago:
   
   a) Change in field value ÷ Distance = Gradient
E. Mapping an air pressure field –

1. Isobars are drawn in intervals of ________ in the US.
   a) Decode station model pressure readings by adding a 9 or a 10 to the front of the number and a decimal between the last two digits.
   b) 040 = ____________, 120 = ____________, 759 = ____________

2. Connect points of equal air pressure in intervals of 4 mb.

Identify areas of high or low pressure by labeling the middle with an H/L.

XI. Weather Trends/______________:

   A. Weather systems move ____________ to ____________ across the USA.
      1. This trend is caused by the _________________; due to Earth’s rotation from ____________ to ____________.

   B. Regent’s Maps - contain ____________ models and/or ____________.
C. Extreme Weather:

1. Hurricanes -
   a) ______ pressure; storm systems
   b) Fueled by energy ______________ over _______ ocean water.
      (1) Fueling is caused by ____________________.
   c) ______________ energy over land; loses fuel source.
   d) Extremely high ________; blowing ________.

![Hurricane Image]

2. Tornadoes -
   a) A violently rotating ______________ of air, in contact with the ground.
   b) Stems from a ______________ cloud or just underneath a cumulus cloud.
   c) Often visible as a ______________ cloud.
   d) Cause:
      (1) _________ air moves over _________ air.
      (2) During developing ______________________
      (3) Typically in the _________________

![Tornado Image]
Climate & Meteorology
How would you describe the climate you live in to an out-of-town guest?

- Include in your description:
  - The best/worst time of year? Why?
  - Environmental changes

- Is there one word you can use to summarize the pattern of weather you experience?
Climate

I. Climate - The weather conditions, including temperature, precipitation, and wind, that characteristically occur in a particular region.
   - An area’s **long-term pattern of weather**.

A. Factors affecting Climate:
   1. Latitude
   2. Altitude
   3. Ocean Currents
   4. Marine vs. **Continental**
   5. **Orographic** Effect
1. Latitude & Insolation
   a) Higher latitudes have **cooler** temperatures, because they receive less direct **insolation**.

1) **Indirect** insolation
   a) short daylight periods, **long** shadow, winter

2) **Direct** insolation
   a) long daylight periods, **short – no** shadow, summer
Latitude vs. Average Yearly Temp

b) **Average** Yearly Temperature (AYT)
   
   1) Mathematical average of temperature measurements taken every day for one year.

   2) As *latitude increases*, average *temperature decreases.*
Latitude vs. Yearly Temp Range

c) Yearly Temperature Range (YTR)

1) **Maximum** and **minimum** temperatures for a particular area during a **one year** period.

2) **As latitude increases, temperature ranges increases**
<table>
<thead>
<tr>
<th>Location</th>
<th>Average Yearly Temperature</th>
<th>Yearly Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valdivia, Chile</td>
<td>53°F</td>
<td>(46°F – 62°F) 16°F</td>
</tr>
<tr>
<td>Peking, China</td>
<td>53°F</td>
<td>(24°F – 79°F) 55°F</td>
</tr>
</tbody>
</table>
Climate Factors

2. Altitude - *elevation* especially *above sea level* or above the earth's surface
   
   a) As *altitude increases*, average temperature decreases.
3. **Ocean Currents**: may make the climate of coastal regions warmer or cooler than normal for that latitude.
Ocean Currents

➢ Warmer or colder than normal?
  o East Coast of N.A.
  o East Coast of S.A.
Marine vs. Continental

a) **Land gains** and loses heat much **faster** than water.

1) Land areas tend to have:
   a) *Hotter Summers* and *Colder Winters*
   b) Continental Climates; **High temperature range**

2) **Coastal areas**; near large bodies of water tend to have:
   a) *Cooler Summers* and *Warmer Winters*
   b) Marine Climates; **low temperature range**
Marine Vs. Continental

- Location X:
  __________ climate
  __________ YTR

- Location Y:
  __________ climate
  __________ YTR
Orographic Effect & **Rain Shadow Effect**

1) Orographic Effect
   - **Windward** side
     a) Wetter and Cooler
     i. Seattle, Hawaii, Amazon Valley

2) Rain Shadow Effect
   - **Leeward** side
     a) Dryer and Warmer - cooler nights
     i. Death Valley, deserts of Peru
1. Rises
2. Expands
3. Cools
4. Condenses
5. Cloud Formation
6. Sinks
7. compresses
8. Warms

Orographic Effect
Windward

Rain Shadow Effect
Leeward
Rainfall Factors

1. Latitude - **Uneven heating** produces global **wind** and air **pressure** belts.
   - “Pressure belts” determines the wetness or dryness of a particular area
     a) Low pressure; **Wet**
     b) High pressure; **Dry**
Latitudes vs. Rainfall

1) What latitudes are areas of rainfall/wetness?

2) What latitudes are areas that lack rainfall/dryness?
Areas of Rainfall

a) Regions on Earth where air **rises**, **expands**, **cools** (to dew pt.), **condenses**, forms clouds and precipitates

1) **Windward** side of a mountain
Areas of Rainfall

2) **Doldrums** - the **equatorial** regions where warm humid air rises as a result of **convection**.

a) Produces thunderstorms almost **daily**.
Distance from the Sea vs. Prevailing Winds

2. Areas of rainfall

b) Where prevailing winds blow in from the ocean; there is generally more rainfall
3. Areas of Little Rainfall

a) Regions on Earth where air sinks, compresses, warms and becomes less humid or drier.
   1) Leeward side of mountain
   2) Horse (mid) latitudes
   3) High pressure systems

b) Where prevailing winds blow from the interior of a continent; there is generally less rainfall.
C. Region/Climate Comparisons

1. Death Valley, California - 1 in/yr

2. Cherrapunji, India – 456 in/yr

3. Amazon Valley, South America
   - Rains everyday

1. Deserts of Peru
   - Doesn’t rain for years at a time
Cause and Effect

- Illustrate or describe why your local climate is classified as a temperate climate.
  - What factors influence our yearly weather patterns?
  - Which factors influence our daily weather?
Comparisons

- How has climate different from weather?
- By what criteria is daily weather analyzed?
Meteorology

The scientific study of the atmosphere that focuses on *weather processes, patterns and forecasting.*
Weather

II. The state, or **condition**, of atmospheric **variables** for a location at **any given time**.

A. Atmospheric Variables:

1. **Temperature** → °F or °C
2. **Wind** → Speed = **knots**, & Direction = **NSEW**
3. **Moisture** → Precipitation = **in**
   → Humidity = **%**

1. **Air Pressure** → **millibars**
   → **inches of Mercury**
Causes of Weather

1. Amount of **insolation**
   - **INcoming SOLar radiATION**
     - a) Indirect
     - b) Direct

2. The uneven heating of Earth’s surface
   - a) Surface heating is dependent on **angle and duration** of sunlight.
b) The uneven heating of Earth’s surface causes the atmosphere to react and produce an infinite variety of weather conditions.
Weather Instruments

Barometer
measures
Air Pressure

Sling Psychrometer
measures
Relative Humidity & Dew Point

Rain Gauge
measures Rainfall
Weather Instruments

Wind/Weather Vane
measures
Wind Direction

Anemometer
measures
Wind Speed

Thermometer
measures
Temperature
Atmosphere

III. The shell of air (*mixture of gases*) that surrounds Earth.

A. Composition of the Atmosphere:
   1. 78% - **Nitrogen**: used by bacteria, plants...
   2. 21% - **Oxygen**: used by plants and animals.
   3. 0-4% - **Water Vapor**: cloud formation, rainbows,...
   4. .93% - Argon: inert gas, used in light bulbs, welding...
   5. .04% - **Carbon Dioxide**: used by green plants
   6. .01% - **Other Gases**: Helium, Hydrogen, **Ozone** (O₃), Krypton, Neon, Xenon
   7. Dust Particles (**Condensation Nuclei**)
Temperature vs. Altitude

- Combine your drawing of the composition with the atmosphere with this diagram.
Heat Budget

1. 6%: Reflected by **aerosols**; dust particles and water droplets.
2. 20%: **Reflected** by clouds
3. 4%: Reflected by **Earth’s surface**
4. 3%: Absorbed by **clouds**
5. 51%: Absorbed by **Earth’s surface**
6. 16%: Absorbed by **ozone**, water vapor and dust
The Atmosphere & Solar Energy

100 Units Of Insolation

Surface Of Earth
The Atmosphere & Radiation

Diagram showing Earth Radiation Components, including:
- Incoming Shortwave Radiation
- Reflected Shortwave
- Top of atmosphere
- Outgoing Longwave
- Clear-sky Greenhouse Effect
- Terrestrial Longwave Radiation
- Cirrus
- Longwave Emission of Clouds
- Clear-sky Greenhouse Effect
- Low Clouds
Temperature & Heat

A. Heat transfer: how heat moves
   1. Conduction: heat is transferred through the collision of molecules.
      a) Occurs best in solids (particles are closer.)
         Molecules vibrate faster when heat is applied
2. **Convection** - Heat is transferred through actual movement of a heated liquid or gas.
   
a) As **warm** water rises it mixes with **cold** water and creates an up and down pattern; called convection currents.
3. Radiation - Heat is transferred by wave motion through air or space.
   a) Heat, light and other electromagnetic waves travel through a vacuum from the Sun to the Earth daily

Example: Insolation - Solar radiation
Heat Transfer

- Draw an illustration of all three types of heat transfer.
Factors that Affect the Rate of Heating

1. **Angle** and **Duration** of Insolation
   
   a) **Season/Time of day:**

   1) The angle of **insolation changes** in the course of one day/season; **max.** intensity occurs at **noon/summer**.
Specific Heat

The amount of heat per unit mass required to raise the temperature by one degree Celsius.

- The relationship between heat, energy storage, and temperature change.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>SPECIFIC HEAT (Joules/gram °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid water</td>
<td>4.18</td>
</tr>
<tr>
<td>Solid water (ice)</td>
<td>2.11</td>
</tr>
<tr>
<td>Water vapor</td>
<td>2.00</td>
</tr>
<tr>
<td>Dry air</td>
<td>1.01</td>
</tr>
<tr>
<td>Basalt</td>
<td>0.84</td>
</tr>
<tr>
<td>Granite</td>
<td>0.79</td>
</tr>
<tr>
<td>Iron</td>
<td>0.45</td>
</tr>
<tr>
<td>Copper</td>
<td>0.38</td>
</tr>
<tr>
<td>Lead</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Factors that Affect the Amount/Rate of Heating

3. Land vs. Water
   a) Land heats and cools faster than water

4. Color: Dark vs. Light
   a) Dark colors heat up faster than lighter colors

5. Texture: Smooth vs. Rough
   a) Rough surfaces heat up faster (more surface area)
Measuring Temperature

<table>
<thead>
<tr>
<th>Fahrenheit</th>
<th>Celsius</th>
<th>Kelvin</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>110</td>
<td>380</td>
</tr>
<tr>
<td>200</td>
<td>100</td>
<td>370</td>
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<td>180</td>
<td>90</td>
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<td>300</td>
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<tr>
<td>40</td>
<td>20</td>
<td>290</td>
</tr>
<tr>
<td>20</td>
<td>10</td>
<td>280</td>
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<td>0</td>
<td>0</td>
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<td>-30</td>
<td>250</td>
</tr>
<tr>
<td>-60</td>
<td>-40</td>
<td>240</td>
</tr>
<tr>
<td>-80</td>
<td>-50</td>
<td>230</td>
</tr>
<tr>
<td>-100</td>
<td>-60</td>
<td>220</td>
</tr>
</tbody>
</table>

- 212 °C - Water boils
- 99 °C - Body temp
- 68 °C - Room temp
- 32 °C - Water freezes
- 195 °C - Dry ice
- 77 °C - Air freezes
- 0 °C - Absolute zero
Connecting Main Ideas

- Illustrate how heat transfer varies with in the atmosphere and on Earth’s surface.
  - Use previous diagrams to guide ideas
    - More than one drawing may be necessary
  - How do composition, texture, and color influence heat transfer?
  - What characteristics of the atmosphere redirect heat?
Moisture

- Dampness that can be felt as vapor (gas) in the atmosphere or liquid on the surface of objects.
The Water Cycle

1. The primary source of **energy** for the water cycle, is the Sun.

2. Transpiration (evapo-) is the process by which **plants** release **water** into the atmosphere.

3. **Precipitation** is falling liquid or solid water from the clouds to Earth’s surface.
   - Rain, Snow, Hail, Sleet…
Changes in States of Matter

1. States of matter
   a) Solid
   b) Liquid
   c) Gas
2. Phases: How they **change**;

pg 1 of ESRT’s

a) **Evaporation & Condensation**

b) **Melting & Freezing**

c) **Sublimation & Deposition**

---

**Properties of Water**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat energy gained during melting</td>
<td>334 J/g</td>
</tr>
<tr>
<td>Heat energy released during freezing</td>
<td>334 J/g</td>
</tr>
<tr>
<td>Heat energy gained during vaporization</td>
<td>2260 J/g</td>
</tr>
<tr>
<td>Heat energy released during condensation</td>
<td>2260 J/g</td>
</tr>
<tr>
<td>Density at 3.98°C</td>
<td>1.0 g/mL</td>
</tr>
</tbody>
</table>

*Each of these paired phase changes occurs at the **same** temperature, depending on the material.*
Solid ↔ Liquid

a) **Melting:** occurs when a solid changes into a liquid; by warming.
   
   1) Water must **absorb** 334 calories of **energy**/heat to convert 1g of ice to liquid water.

b) **Freezing:** Occurs when a liquid changes into a solid.
   
   1) Water molecules **release** energy equivalent to the **energy** absorbed during melting.
a) **Evaporation**: occurs when a liquid changes into a *gas*; by warming.
   1) Water must **gain** 2260 calories of energy to convert 1g of liquid water to water vapor.

b) **Condensation**: occurs when water vapor changes into a liquid.
   1) Water molecules **release** energy equivalent to the energy absorbed during evaporation.
   2) Condensation in the atmosphere results in the formation of **clouds** and **dew/fog/frost**.
Heat required to take 1 gram of ice at $-100\,^\circ\text{C}$ to vapor at $200\,^\circ\text{C}$
Factors Affecting the Rate of Vaporization

a) Temperature: as temperature increases, the rate of evaporation increases.

b) Humidity: as humidity increases, the rate of evaporation decreases.
Factors Affecting the Rate of Vaporization

c) Wind: As wind speed increases; the rate of evaporation increases.

d) Surface Area: As surface area increases, the rate of evaporation increases.
Factors Affecting the Rate of Vaporization

e) Specific Heat: As specific heat increases, the rate of vaporization decreases.
Solid ↔ Gas

- **Sublimation**: Occurs when a solid changes directly into a gas.
  - Mothballs and **Dry ice** ($\text{CO}_2$)

- **Deposition**: Occurs when a gas changes directly into a solid.
Changes in State

Deposition 2260 J/g

M Melting 334 J/g
Freezing

Evaporation 2260 J/g
Condensation

particles are tightly packed
particles have looser bonds
the bonds are broken

Sumblimation 2260 J/g

= Absorbs Heat
= Releases Heat
Moisture in the Atmosphere

- The primary source for moisture in the atmosphere is the ocean.
  - Other sources include: lakes, rivers, soil, plants...

1. Water exists in all three states
   a) Solid – Minute crystals suspended in the air
   b) Liquid – Minute droplets suspended in the air
   c) Gas – Water Vapor
Moisture in the Atmosphere

2. **Humidity** is the general term used to describe the **amount** of water **vapor** in the air.

3. **Temperature** determines the amount of water vapor the air can **hold**.
   a) As air temp. **increases**, the amount of water vapor the air can hold increases.
Moisture in the Atmosphere

4. Saturation occurs when the air holds as much water vapor as it can; at a given temperature.
Saturation

a) Occurs when Evaporation = Condensation

- no evaporation has occurred
- evaporation > condensation
- evaporation = condensation.

Saturation

- air molecule
- water molecule

Evaporation

Condensation
Moisture in the Atmosphere

5. Dew Point Temperature: the temperature to which air must be cooled to reach saturation.
   a) Measured with a sling psychrometer
      1) Two thermometers held together; one wet thermometer bulb and one dry thermometer.
         o Whirl for 1 minute
Reading a Sling Psychrometer

2) Evaporation occurs on the wet bulb; causing its temperature to drop.

3) The difference between the dry bulb and the wet bulb determines the dew point and relative humidity of the air
   a) At saturation, the temp. difference between dry and wet bulbs would be 0.
      i. Drier the air results in larger differences; causes faster/more evaporation; resulting in more cooling.
      ii. More humid air results in smaller differences; causes slower/less evaporation; resulting in less cooling.
<table>
<thead>
<tr>
<th>Dry-Bulb Temperature (°C)</th>
<th>Difference Between Wet-Bulb and Dry-Bulb Temperatures (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15</td>
</tr>
<tr>
<td>-20</td>
<td>-20 -33</td>
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<tr>
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<td>28 27 25 24 22 21 19 17 16 14 11 7 4 1 -3</td>
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<td>30</td>
<td>30 29 27 26 24 23 21 19 18 16 14 12 10 8 5 1</td>
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## Determining Dew Point

<table>
<thead>
<tr>
<th>Dry Bulb Temp</th>
<th>22°C</th>
<th>22°C</th>
<th>20°C</th>
<th>15°C</th>
<th>9°C</th>
<th>8°C</th>
<th>17°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Bulb Temp</td>
<td>20°C</td>
<td>13°C</td>
<td>14°C</td>
<td>12°C</td>
<td>3°C</td>
<td>6°C</td>
<td>17°C</td>
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<tr>
<td>Difference</td>
<td></td>
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<td>Dew Point</td>
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</tbody>
</table>
6. **Relative Humidity**: the ratio between the **actual** amount of water **vapor** in the air to the **maximum** amount of water vapor the air can **hold** at a certain temperature.
Relative Humidity vs...

Temperature:

1) If the temperature **increases**; and **moisture** in the air remains the same; relative humidity will **decrease**.

2) Time of day:
   a) **Highest** RH: **coolest** time of day; ~ 5:00 am
   b) **Lowest** RH: **warmest** time of day; ~ 3:00 pm
b) Absolute Humidity: the **actual** amount of water vapor in the air.

1) If **moisture** content of the air increases; and **temp** remains the same; relative humidity will **increase**.
<table>
<thead>
<tr>
<th>Dry-Bulb Temperature (°C)</th>
<th>Difference Between Wet-Bulb and Dry-Bulb Temperatures (°C)</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
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<tr>
<td>-20</td>
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<td>-18</td>
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<td>28</td>
<td>100</td>
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<tr>
<td>30</td>
<td>100</td>
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</tbody>
</table>
## Determining Relative Humidity

<table>
<thead>
<tr>
<th>Dry Bulb Temp</th>
<th>20°C</th>
<th>8°C</th>
<th>22°C</th>
<th>22°C</th>
<th>15°C</th>
<th>15°C</th>
<th>3°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Bulb Temp</td>
<td>14°C</td>
<td>6°C</td>
<td>13°C</td>
<td>20°C</td>
<td>12°C</td>
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<td>-1°C</td>
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<tr>
<td>Difference</td>
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<td>Relative Humidity</td>
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</tr>
</tbody>
</table>
Clouds

7. Clouds are tiny droplets of **liquid** water or tiny **ice** crystals suspended in air.
   a) Conditions needed for cloud formation:
      1) **Moisture** in the air
      2) **Cooling** Temperatures
      3) CONDENSATION **NUCLEI**

   a) Aerosols in the atmosphere which provide a surface for water molecules to condense upon. Ex: Dust particles, salt particles, ...

   b) Precipitation **cleans the air.**
      o The aerosols used as condensation nuclei are removed from the atmosphere during precipitation.
Adiabatic Cooling

c) Cooling in the atmosphere

1) As a parcel of air rises, the air pressure surrounding a parcel of air decreases

2) The parcel of air expands in volume as it rises. As it expands in becomes cooler

3) When the temp. of this parcel of air falls to its dew point temp., the water vapor in the air condenses and a cloud appears in the sky
Cloud Types

d) Key terms:
   1) **Cirrus**: wisps or curls
   2) **Stratus**: spread or layered
   3) **Cumulus**: heaps or piles
   4) **Alto**: prefix meaning “high”
   5) **Nimbus**: rain-bearing or snow-bearing

- Draw as many combinations as you can
Classification of Clouds

- **Cirrostratus**
- **Cirrocumulus**
- **Cirrus**
- **Altostratus**
- **Altostratus**
- **Altocumulus**
- **Middle Clouds**
- **Cumulus**
- **Stratus**
- **Stratocumulus**
- **Nimbostratus**

Clouds with Vertical Development:

- **Cumulonimbus**
Connecting Main Ideas

- Illustrate and describe the relationships between the atmosphere, moisture and daily weather changes
VI. The force of gravity causes the air to have weight; this creates air pressure.
Inches of Mercury (Hg)

A. Air pressure acts equally in all directions
   1. All objects that contain air have air pressure.
      a) Buildings, human body, bottles, . . .

B. Measuring air pressure:
   1. Air Pressure at sea level is 14.7 lbs/in²
2. Standard **sea level** atmospheric pressure is:
   a) **One atmosphere** (atm)
   b) **29.29 in** of Mercury (Hg)
   c) **1013.2 mb** (millibars)

3. Use page **13** in ESRT’s to convert mb into inches of Hg.
   o **997 mb**
   o **30.15 in**
   o **982 mb**
   o **29.53 in**
Measuring Air Pressure

Aneroid Barometer

Mercury Barometer

Millibars

Inches of Hg

29.92 in
Changes in Atmospheric Pressure

C. Factors
- Temperature
- Moisture
- Altitude

1. Temperature - As air temp. increases, air molecules move farther apart and the air becomes less concentrated) and the air pressure will decrease.
2. Moisture - As **humidity increases**, air pressure **decreases**.

   a) Moist/humid air contains more water **vapor**

   b) Water vapor molecules are **lighter** than the **heavier** dry air molecules the replace

   c) Replacement occurs during **evaporation**
Moisture v Pressure

- High Pressure → Dry air weighs more
  - contains Nitrogen, Oxygen and Carbon Dioxide;
    Nitrogen = 28g, Oxygen = 32g, CO₂ = 44g
- Low Pressure → Humid air weighs less
  - contains Nitrogen, Oxygen, Carbon Dioxide and
    Water Vapor = 18g
3. Altitude - As altitude **increases**, air pressure **decreases**.

a) At **higher** altitudes there is less air above you and the air is less **dense**.
Connecting Main Ideas

- What factor influence air pressure?
- How does air pressure effect our weather?
Wind

VII. The **horizontal** movement of air; **parallel** to Earth’s surface.

A. Causes of Wind:

1. **Uneven** heating of Earth’s surface
   
   a) Land vs. **Water**
   
   b) **Poles** vs. Equator
   
   c) Dark Forest vs. **Snowfield**

2. Winds help distribute **energy** from regions of **surplus** energy to regions of energy **deficit**
B. Sea breeze vs. Land breeze

1. Sea Breeze – day-breeze
   a) Land is warmer and **less dense**; **low** Pressure
   b) Air over Lake Ontario is cooler and **more dense**; **High** pressure.
B. Sea breeze vs. Land breeze

2. Land Breeze – night-breeze
   a) Land air is cooler and more dense; high pressure
   b) Air over Lake Ontario is warmer and less dense; low pressure
Wind Direction

C. Winds always blow from regions of high pressure to regions of low pressure.

1. The Coriolis Effect:
   a) Earth’s rotation on its axis causes winds to be deflected.
      1) Northern hemisphere - to the right, clockwise
      2) Southern hemisphere - to the left, counter-clockwise
Global Winds

b) Caused by the unequal distribution of insolation.

Non-rotating Earth

Rotating Earth
Cyclones vs. Anticyclones

a) Anticyclones – high pressure systems

1) Winds move in a clockwise outward spiral around a high pressure system.
   - Hi-Clock; High-Clockwise
Cyclones vs. Anticyclones

b) Cyclones – **Low** pressure system

1. Winds move in a **counter-clockwise inward** spiral around a low pressure system
   - Low-Counter; Low-Counterclockwise
Side View

Side/profile View:

Chicago  |  Buffalo  |  Boston

H        |  L        |
Wind Speed

D. The speed of the wind is determined by the difference in air pressure

1. Pressure gradient: Differences in air pressure between two places
   a) As the pressure gradient increases, wind speed increases

2. Measured in Knots \( \rightarrow 1 \text{ Knot} = 1.5 \text{ mi/hr} \)
Pressure Gradient

- Where is the pressure gradient the greatest?
- Where are the winds strongest/highest wind?
- What is the gradient between Niagara Falls and Rochester? (Distance = 24 miles)
Air Masses

VIII. Air Mass: a large body of **air** in the **troposphere** with similar characteristics
   - **Temperature, moisture** and **pressure**

A. Source Region: a geographic region where an air mass is formed
   1. Picks up **characteristics of the surface** over which it formed.
B. Types of Air Masses

1. Tropical: originates in **tropical** regions
   a) High temps

2. Polar: originates in **polar** regions
   a) Low temps

3. Arctic: originates in **ice covered** areas
   a) Very **cold** and **dry**

4. Equatorial: originates over **equator**
   a) Very **hot** and **humid**

5. Continental: originates over **land masses**
   a) Dry

6. Maritime: originates over **water**
   a) Wet, moist
### C. Air masses are a combination of temperature and moisture conditions.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Source Region</th>
<th>Name of Air Mass</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Continental Polar</td>
<td>Cold &amp; Dry</td>
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<tr>
<td>mT</td>
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<td>Warm &amp; Moist</td>
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<td>Warm &amp; Dry</td>
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<td>Maritime Polar</td>
<td>Very Cold &amp; Very Dry</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cold &amp; Moist</td>
</tr>
</tbody>
</table>
USA – Source Regions

- Label the map.
Connecting Main Ideas

- Create a mind map showing the connections between moisture, pressure and wind.
IX. Weather Fronts - a boundary between air masses
Cold Front

A. The leading edge of a cold air that **advances** and **displaces** warmer air.

1. A narrow band of **heavy rain** usually precedes a cold front.
Warm Front

B. The leading edge of warm air that **advances** and **displaces** colder air.

1. A wide band of **light steady showers** precedes a warm front.
Weather Fronts

C. Stationary: two different air masses move parallel to each other and Earth’s surface

D. Occluded: two or more air masses interact and combine at their boundaries.
Types of Fronts and Map Symbols

The Cold Front
- Cold Air Advancing
- Warm Air Retreating

Fig 54

The Warm Front
- Cold air retreating
- Warm air advancing

Fig 55

The Stationary Front
- Cold air
- Warm air

Fig 56

Occluded Front
- Cool Air in Place
- Colder Drier Air Mass
- Warm Front
- Warm Moist Air Mass
- Cold Front
E. Page 5 of ESRT’s

Key to Weather Map Symbols

Station Model

28
$\frac{1}{2}$
27
196
+19/
.25

Station Model Explanation

Amount of cloud cover (approximately 75% covered)

Temperature (°F) 28

Visibility (mi) $\frac{1}{2}$

27

Dewpoint (°F) 196

Barometric pressure (1019.8 mb)

Barometric trend (a steady 1.9-mb rise in past 3 hours)

Precipitation (0.25 inches in past 6 hours)

Wind direction (from the southwest)

Wind speed (1 knot = 1.15 m/h)

Whole feather = 10 knots

Half feather = 5 knots

Total = 15 knots

Present Weather

Drizzle

Rain

Smog

Hail

Thunderstorms

Rain showers

Snow

Sleet

Freezing rain

Fog

Haze

Snow showers

Air Masses

cA continental arctic

cP continental polar

cT continental tropical

mT maritime tropical

mP maritime polar

Fronts

Cold

Warm

Stationary

Occluded

Hurricane

Tornado

Symbols for Precipitation

Total Sky Cover

- No clouds
- Less than one-tenth or one-tenth
- Two-tenths to three-tenths
- Four-tenths
- Five-tenths
- Six-tenths
- Seven-tenths or eight-tenths
- Nine-tenths
- Completely overcast
- Sky obscured
If you were a weather reporter; how would you communicate what you see to your TV audience?

On your map use any of the following to show weather qualities and patterns that you observe:

- Air masses
- Pressure System
- Weather Fronts
- Station Models
Isolines

A. Isoline
   1. A line connecting points of equal value.
      a) Isolines help to see **patterns** on a map

B. Isotherm
   1. Lines that connect points of equal **temperature**.
      a) Points of equal value connect linearly across the US.

C. Isobars
   1. Lines that connect points of equal **pressure**
      a) Points of equal value connect in **circles** on a map
Mapping a Temperature Field
2. The greatest temperature gradient is between which two cities?
   a) Indicated because the isotherms are **closer together**

3. What is the temperature gradient from Cincinnati to Chicago? (Distance = 296 mi)
   a) Change in temp ÷ distance
Mapping an Air Pressure Field

1. ISOBARS are drawn in intervals of 4 mb in the US.
   a) Look for 3-digit number at top right of circle.
      o Add either a 9 or 10 to the front of the original map number.
         o Add a 9 if original was above 500
         o Add a 10 if original number was below 500.

   o 040=_________, 120=_________, 759=_________

2. Use this new knowledge to draw the correct isobars on the map.
Weather Trends

A. Weather systems move **west** to **east** across the USA.
   1. This is due to the **Coriolis Effect** caused by Earth’s rotation from **west** to **east**.

B. Regents Maps:
   - Contain **Station** Models or **isolines**
Hurricanes

a) **Low** pressure; storm system
b) Fueled by energy **absorbed** over **warm** ocean;
   1) Fueling is caused by **evaporation**.
c) **Releases** energy over land; loses fuel source
d) Extremely high **winds**; blowing **rain**....
Tornadoes

a) A violently rotating **column** of air, in contact with the ground,
b) Stemming from a **cumulus** cloud or underneath a cumulus cloud
c) Often visible as a **funnel** cloud
d) Causes:
   1) **Cold** Air moves over **warm** air.
   2) During the development of **thunderstorms**
   3) Typically in the **mid-west**.
Reviewing Main Ideas

- Choose your best ideas from previous mind maps.
- Create a map with your peers that illustrates the qualities that describe or influence the weather.
### Astronomy

**Strategy:** Activating Cognitive Schema

**Modes of Communication:** Descriptive, pictorial

**Rational:** As students explore what they know about a new topic and how they may identify with it, they are required to activate the schema necessary to continue learning about the topic at hand. This strategy creates a pathway for deeper understanding and learning, as ideas are scaffolded throughout the notes. By activating prior knowledge and communicating that knowledge in several different ways students learn to reflect on their understanding of the topic before it is introduced.

**Location(s):**
Page 1, Slide 2

**Reference:**
Thinking Questions; Kagan (1999)

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<table>
<thead>
<tr>
<th>Strategy</th>
<th>Summative Cognitive Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong></td>
<td>Descriptive, textual, pictorial</td>
</tr>
<tr>
<td><strong>Rational:</strong></td>
<td>Throughout the note-packets students are asked to copy and create several drawings. Summative descriptive strategies provide students with the opportunity to combine the main ideas and drawings from within the lecture; into a cohesive statement of understanding. Through this process students and teachers can monitor how students make connections between new ideas and previous knowledge. These strategies provide insight into student comprehension and perception of segmented and holistic scientific systems and processes.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
<td>Page 27, Slide 100 Page 28, Slide 101</td>
</tr>
<tr>
<td><strong>Reference:</strong></td>
<td>Think Trix (2005) Thompson &amp; Thomason (1999)</td>
</tr>
<tr>
<td><strong>Strategy:</strong> Summative Cognitive Reflection</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Modes of Communication:</strong> Depictive, symbolic</td>
<td></td>
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<tr>
<td><strong>Rational:</strong> Units within the Earth Science curriculum, introduce students to major ideas about the physical world around us with tremendous amounts of detail. Students must understand these details to properly communicate the broader ideas within a unit. Summative depictive strategies provide students with the opportunity to work through and review the textual information within their notes. As they review these new ideas and relationships students illustrate their thinking processes through graphic organizers or mind mapping tasks. These strategies allow teachers and students to visualize connections that students are making with new information and promote discussion and assessment of internal comprehension.</td>
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<td>Graphic Organizer; Kagan (1998)</td>
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<td>Thinking Questions; Kagan (1999)</td>
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<table>
<thead>
<tr>
<th><strong>Strategy:</strong> Visual Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes of Communication:</strong> Descriptive, pictorial, iconic</td>
</tr>
<tr>
<td><strong>Rational:</strong> Visual representations are meant to provide students with an illustration of an idea or word without demanding more from their working memory. Visual-descriptive strategies allow students to illustrate properties of an idea, rather than focus on the textual information. Student perceptions of the concept and its properties are prominent in this strategy. Teachers should allow students opportunities to revise or add to images created during note taking.</td>
</tr>
<tr>
<td><strong>Location(s):</strong></td>
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<td>Page 2, Slide 7, 8</td>
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<tr>
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<td>Page 16, Slide 55</td>
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<tr>
<td>Page 18, Slide 67</td>
</tr>
</tbody>
</table>
**Strategy:** Visual Interpretation  

**Modes of Communication:** Depictive, pictorial, symbolic  

**Rational:** Focusing on the textual information provided within the notes students create mental and physical images. The visual-depictive strategy will aid in the creation of mental models as note taking occurs. In each instance the student is asked to interpret the text and create an illustration that depicts their understanding. This creates an internal connection between the student and the concept, as well as supporting informal assessment techniques.

**Location(s):**  
- Page 3, Slide 12  
- Page 6, Slide 21  
- Page 11, Slide 41  
- Page 19, Slide 70  
- Page 19, Slide 72  
- Page 22, Slide 82  
- Page 24, Slide 92  
- Page 26, Slide 98

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**Strategy:** Graphic Interpretation  

**Modes of Communication:** Descriptive, pictorial  

**Rational:** Throughout the Earth Science curriculum and within the NYS Regents exams students are expected to interpret information from and add information to a multitude of diagrams. Within the graphic-descriptive strategy students are asked to analyze diagrams for information and add or pull information from the diagrams based on information provided within the unit. The use of this strategy affords teachers with the opportunity to nurture the use of diagrams, and provides students with a basis for the utilization of diagrams in science.

**Location(s):**  
- Page 12, Slide 42  
- Page 26, Slide 99
### Strategy: Mathematical Representation

**Modes of Communication:** Depictive, pictorial, symbolic

**Rational:** Mathematical-symbolic strategies focus on the development of simple graphic images to represent the relationships between two or more variables. The development of each instance varies from linear to axial locations and labels. Each variation was chosen to draw the attention to the specific variables and how each behaves in relation to one another. Students and teachers should engage in scientific discourse as the relationships are identified and represented.

**Location(s):**
- Page 12, Slide 43, 44

### Strategy: Mathematical Interpretation

**Modes of Communication:** Symbolic, textual

**Rational:** Several equations are used throughout the curriculum to aid in student understanding of illustrated or observed data. These common place equations, in Earth Science, are spread throughout the presentations to provide students with multiple opportunities to practice manipulating and communicating information using the variables and units of measure associated with gradient, rate of change and eccentricity formulas.

**Location(s):**
- Page 13, Slide 48
- Page 22, Slide 82

### Strategy: Kinesthetic Representation

**Modes of Communication:** Depictive, textual, symbolic

**Rational:** Kinesthetic strategies allow students an opportunity to experience an idea that is typically described through textual or verbal communication. Students internalize and analyze movement within this strategy, adding to comprehension and communicative ability within the topic. For more abstract ideas, materials may be manipulated to show the movement of an object or add dimension and perspective to an intangible idea.

**Location(s):**
- Page 23, Slide 89
I. Celestial Observations and Measurement

A. Celestial ______________: The ______________ surface of an imaginary ______________, on which all celestial bodies appear to be projected.

1. It is a model of the sky, shaped like a ______________.
2. ______________ Objects: any natural object in the sky, ______________ of Earth's ______________.
   a) Ex: Stars, ______________, galaxies, ______________
3. ______________ - The highest ______________ in the sky, directly ______________ an observers ______________ on Earth.
4. ______________ - The imaginary ______________ between Earth and sky
5. ______________ - the angular ______________ of a celestial object ______________ the ______________.

![Diagram of Celestial Sphere and Observations](image)
B. The Altitude/Azimuth System – coordinate system for locating stars

1. ____________ - Angular distance along the horizon; from ______ North;
   ____________
   
   [Diagram of horizon system]

2. Find the coordinates for the stars located on the celestial spheres below:

   [Diagrams of celestial spheres with compass and azimuth points]

   compass azimuth compass azimuth

   ________ ________ ________ ________

   altitude altitude

   ________ ________ ________ ________

   compass azimuth compass azimuth

   ________ ________ ________ ________

   altitude altitude

C. The Observed Effects of Earth’s Rotation – 24hrs

1. ____________ - the cyclic ____________ of an object on an ____________.

   a) The Earth rotates on an axis of ________ from 90°.

   b) The Earth makes ________ complete rotation in ____________.
2. ________________ of Earth's rotation -
   a) __________________ Pendulum - an iron sphere attached to a long wire; that rotates in varying degrees daily.
   b) __________________ - the deflection of an object moving above the earth

1) Winds and projectiles are deflected to the ___________ in the _________________ hemisphere

2) Winds and projectiles move to the ___________ in the _________________ hemisphere

3. Night and Day: One __________ of the Earth will experience darkness (night); while the other half experiences ________________ (day.)

4. The Sun's ________________ Motion
   a) The Earth rotates from ___________ to ___________; in a ________________ motion.
   b) This causes the __________ to appear to move from __________ to __________.
5. **Apparent _______ Motion of the Stars**

   a) *Stars follow different paths across the sky depending on the compass direction the observer is facing.*

   ![Diagram of star paths]

   _______ _______ _______ _______

   b) *The apparent daily _______ of celestial objects _______ when the observer's _______ on Earth _______.*

   ![Diagram of celestial objects]

   90°N - _______ 0° - _______ 43°N - _______

   _______ stars rise or set _______ stars rise and set

   c) *_______ objects - constellations or celestial objects that appear to _______ around the North or South _______.*

   (1) These stars never appear to set or move below the observers' horizon.

      (a) Examples: _________, Big Dipper

   d) *_______ - light trails left behind after a camera's shutter stays open for a long time and takes a picture of a star.*

      (1) The angles (°) between star trails can help us tell _______

          the shutter was open.

      (2) The direction of star trails vary depending on the direction the _______ is facing.
D. Earth rotates on an axis/angle as it revolves around the sun.

1. Earth on its axis:

- The Earth's Tilt in relation to the Sun during the 4 Seasons:
  - Winter
  - Spring/Fall
  - Summer
E. The Observed Effects of Earth's Revolution - 365 ¼ days

1. ________________ - the ________________ of one celestial body
   ________________ another celestial body.
   
a) *Earth revolves _________ around the sun in _________ days.*
   
   (1) Rate of change: 360° ÷ 365.25 days = __________

2. ________________ locations and visibility ________________ in the sky
   throughout the ________________.
   
a) *Constellations - a group of _________ that form ________________.*
   
   (1) Ex: Big dipper → Ursa Major → Great Bear
   Orion, Pegasus, Cassiopeia, Zodiac signs...

3. *Seasons - yearly _________; repeats every 365 ¼ days.*
   
a) ________________: *Earth ________________ around the sun, in an*
   *elliptical orbit.*
   *Earth is ________________ on an axis; 23.5°.*
   *Earth's axis ________________ points in the _________ direction.*
4. ___________________________ of the Sun

a) The Sun’s path ______________ as ______________ changes.

(1) The Sun’s path is also ______________ for each ______________

b) Length of ______________

(1) The amount of daylight ______________ with ______________

and ______________

(a) Angle of Daylight vs. Seasons and Latitude

(i) Locations at the equator always receive 12 hours of light.

<table>
<thead>
<tr>
<th>Seasons</th>
<th>North Latitude</th>
<th>90°</th>
<th>60°</th>
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II. Earth's Place in the Universe

A. The ________________________________

1. __________: small, dense, rocky planet.

2. ________________________________: Earth is one of 8 planets that orbit our sun.

3. Milky Way ________________________: our sun is one of an estimated 180 billion stars contained in a spiral galaxy.

4. __________________________: Our Milky Way Galaxy is one of billions of galaxies in an expanding universe.
B. Our Solar System

1. The Sun and all celestial bodies ___________ the sun’s ___________ and ___________ the sun.
2. Main Components – planets, ___________, sun, _________________ belt, comets, ________________.
   
a) Planets –
   
   (1) _________________ - Earth-like Planets
       (a) ___________ planets - closest to sun
       (b) Relatively ___________, rocky, more ___________
       (c) ________________
   
   (2) _________________ - Jupiter-like Planets
       (a) Outer planets/_________________________ - beyond asteroid belt
       (b) Relatively ___________, composed of gases, less ___________
       (c) ________________

3. Models of our Solar System
   
a) ________ centric Model:

   (1) _______________ is at the __________ of the universe.
   
   (2) All celestial objects move around Earth in perfect circles.
   
   (3) Earth is in the center and ____________________________.
   
   (4) Stars are located on a sphere and rotate daily.
   
   (5) The __________, the __________, and each __________ are carried on spheres which revolve around the Earth.

   (6) Does not explain:

       (a) Movement of __________________ pendulum.
       
       (b) Curved path of winds and projectiles; ________________ effect.
b) **Centric Model**

(a) Proposed by Nicholas ________________ and Johannes Kepler.

(b) Copernicus’ Model

(1) The _______ is at the __________ of the universe

(2) All planets move in circles around the sun.

(3) The stars are located on an unmoving sphere far from the sun.

(4) The moon moves in circles around the Earth.

(5) The Earth rotates on an axis from west to east __________

(6) Does not explain

(a) Cyclic __________ in the apparent __________ of the sun.

(b) Cyclic variations in the orbital __________ of planets.

(7) Kepler’s Model

(a) The sun is located near the center of our solar system

(b) The stars are located at various distances from Earth

(c) The _______ of planets were ________________ not circular.

(i) This change in orbital shape explained the cyclic relationships observed with the sun's size and planet orbital speed.
4. Laws of Planetary Motion

a) Newton's Laws of Gravity

(1) All ______ possess gravity and will ______ all other objects with a certain __________ force.

(2) The ______ of an object determines the amount of gravitational force.

   (a) ____________________________

(3) The gravitational force between two objects changes as the distance between them changes.

   (a) ____________________________

b) Newton's Law of Inertia

(1) An object's ____________________________

   unless acted on by an outside __________

c) Inertia + Gravity = ____________________________

(1) Inertia – causes planets to move in a ____________________________

(2) Gravity – ________ the planet the sun.
d) Kepler's Laws of Planetary Motion

(1) The orbital ____________ of each planet is an ____________ and the sun is at one ____________.

(a) ____________________ - a measurement of the shape of an ellipse.

(i) Formula: __________________

(ii) Foci: ________ fixed _________ in an ellipse.

(iii) Major axis – the longest straight ________________ the center of the ________________ through the two foci.

Circle - _________ eccentric

Eccentricity = ______________

E = ______________

E = ______________

Straight line - _________ eccentric

13
(b) **Eccentricity Relationships**

(i) As the _________________ between two foci
    ________________________________, the eccentricity value of the
    _________________________________ moves closer to ______.

(ii) _______________ have highly elliptical orbits.

(2) As a planet orbits the sun, its orbital ____________________________:
    it is ______________________________ when it is ____________________ to the
    sun.

(a) _______________ - the point in orbit ____________________ the sun.

(b) _______________ - the point in orbit ____________________ from
    the sun.

(3) The ____________________ away a planet is from the sun; the
    _____________________ its period/__________ of revolution.

<table>
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<th>Planet</th>
<th>Distance from Sun (millions of miles)</th>
<th>Period of Revolution</th>
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<td>Jupiter</td>
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<td>Neptune</td>
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</table>
C. The Milky Way Galaxy

1. Our sun is one of an estimated ___________________________ stars that make up the Milky Way Galaxy.

2. The Milky Way is a ___________________________.

[Diagram of the Milky Way showing the Sun, Nuclear Bulge, Disc, and Globular Cluster]
a) Galaxies are billions of stars ____________________________,
and have three general shapes.

(1) Spiral

(2) ________________

(3) Irregular

III. The Universe

A. Evolution of the Universe

1. ________________ Theory

   a) In the 1920’s, Edwin ________________ discovered that all galaxies were
   moving away from Earth and each other, and so the ________________
   is ____________________________.

   b) The Big Bang Theory – the universe has evolved from an ________________
   of matter and energy.

   Cosmic Evolution: Billions of Years Ago (bya)
B. Energy in Space

1. Energy – energy is transferred through space by various __________.

2. The sun is a major cause of weather and other changes on Earth’s surface.
   a) __________ comes from the sun in many different __________.
   b) Energy from the sun is called the Electromagnetic __________.

3. The __________ Light Spectrum
   a) Continuous Spectrum: unbroken __________; containing all wavelengths;
b) _________________ Spectrum
(1) Different _________________ appear as bright __________ at
different places on the spectral field.
(2) Produced by a chemical ________________ in the form of glowing ________

<table>
<thead>
<tr>
<th>V</th>
<th>I</th>
<th>B</th>
<th>G</th>
<th>Y</th>
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<td>Mercury</td>
<td></td>
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</tbody>
</table>

c) Dark-line _________________ Spectrum: a continuous spectrum with
dark lines.
(1) Dark lines show where certain _________________ are
    absorbed.
(2) Produced by _________________, as a continuous spectrum
    passes through a cooler ________________.
(3) ________________ in the gas ________________ certain
    wavelengths, that would normally produce bright lines.
d) Composition of Stars – Circle the elements that are in the star

4. _______________ Effect – Apparent _______________ in wavelength of __________

or sound.

a) This occurs as an object moves __________ or ___________ an observer.

b) ___________ Shift – Blue ___________

(Earth Laboratory)
c) **Red Shift Vs. Distance**

1. The ____________ of “red-shift” is a ____________ of the ____________ at which a galaxy is moving.

2. As the distance from Earth _________________, the amount/__________ of the red-shift of a galaxy also ________________.

3. The ______________ away a galaxy is, the ______________ it is moving.

---

5. **Measurement of Stars**

a) ______________ - how bright a star “______________.”

1. This depends on its ________ and ________________; in relation to the ________.

2. The luminosity value of the sun is ________.

b) **Apparent Magnitude** - a star ________________ as seen by and observer ________.

c) **Characteristics of Stars**

---

**Diagram of Star Characteristics**

- Mass
- Luminosity
- Surface Temperature
- Color

<table>
<thead>
<tr>
<th>Characteristics of Stars</th>
<th>Masses of Stars</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHARACTERS OF STARS</td>
<td>PG ______ ESRT's</td>
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</tbody>
</table>

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d) **Light year** - The ________________ that light travels in ________________.

(1) The speed of light is $1.86 \times 10^5$, ________________ miles/sec.
   
   (a) That is about 6 trillion miles in 1 year.

(2) We see all night stars and galaxies as they were when the ________________
    ________________.

(3) When we look at distant stars and galaxies we look ________________.
   
   (a) **Alpha Centauri**: __________ light years away; light we see is 4.37
       years old.
   
   (b) **Sirius**: 8.6 light years away; light we see is ______ years old.
   
   (c) **Andromeda Galaxy**: light is ________________ years old.
IV. The Moon – a natural _____________ of the Earth

A. Physical Properties of the Moon

1. Size – diameter: ______________
   a) Relative to Earth – \( \frac{\text{Moon(d)}}{\text{Earth (d)}} = \) __________ = ________

2. _______________ - __________ the gravity of Earth
   a) Smaller = __________ mass = __________ gravitational __________

3. Atmosphere - gases ______________ into space due to ______________

4. Temperature - the lack of an atmosphere causes poor _______________
   on the moon surface.
   a) 240°F on the ____________ side.
   b) __________ on the dark side.

5. Surface Features - ________________
   a) ______________ - bowl shaped depressions that formed usually as a result
      of the ______________.
      (1) Copernicus
      (2) Kepler
      (3) Tycho
   b) ______________ - appear as bright
      streaks; radiate __________ from
      __________.  
   c) Highlands - appear as _______________
      (1) contain craters and ______________.
   d) There are more craters on the Moon than on Earth because,
      (1) The moon has no atmosphere to
         (a) _______________ meteors
         (b) Cause ___________ to wear away impact craters.
e) Maria – dark areas on the moon, believed to be ancient “_________”

(1) Circular plains resulted from __________________________ early in the moons formation.

6. The Moon’s Revolution
   a) Period of Revolution – 27.3 days ~ ___________________
   b) The moon revolves around the Earth in an highly ___________________
   c) This causes the moon’s apparent diameter to change in a _____________ manner.

7. The Moon’s Rotation –
   a) ___________________ - the side of the moon that always faces Earth.

      (1) Always faces Earth because the moon’s period of ____________________
          is ___________________ to its period of ____________________.
   b) ___________________ - the side of the moon that never faces Earth.

B. Phases of the Moon – 27.3 day cycle ~ 1 month

1. Causes - The moon’s ____________________ around Earth and the reflection of ____________________.

2. Moon Phases - Our ____________________ of the illuminated parts
   ___________________________ that faces Earth.
   a) __________
   b) Crescent
   c) Quarter/__________
   d) Gibbous
   e) __________
3. ____________________ - the ____________________ of the moon's visible illuminated surface; from ________ moon to ________ moon.

New → Waxing Crescent → First Quarter → Waxing Gibbous → Full

4. ____________________ - the ____________________ of the moon's visible illuminated surface; from ________ moon to ________ moon.

Full → Waning Gibbous → Third/Last Quarter → Waning Crescent → New

5. Phases of the Moon and the Moon's location in its revolution.
   a) The Moon orbiting Earth as viewed from space.
   b) Phases of the Moon as viewed from Earth.
C. Eclipses – the total or partial ____________ of one celestial body by another

1. Type of Eclipse – depends on the location of the Earth, Moon and Sun.
   a) Lunar ____________ - when the Moon’s orbital path crosses through ____________ shadow.
   b) ____________ Eclipse – when the ____________ orbital path crosses between the ____________ and ____________.

2. Parts of an Eclipse –
   a) Umbra- the ____________ part of an eclipse/___________, due to a complete lack of light.
   b) ____________ - a region of partial shadow located ____________ the ____________.

![Diagram of Lunar Eclipse: Sun, Earth, Moon]

(1) Lunar Eclipse: Sun, Earth, Moon

![Diagram of Solar Eclipse: Sun, Moon, Earth]

(2) Solar Eclipse: Sun, Moon, Earth

D. The Moon and The Tides –

1. Tides are the periodic ____________ and ____________ of the ____________.
   a) Caused by the ____________ pull.
   b) Affected by Earth’s ____________.
2. Spring Tides – occur when the Sun, Moon and Earth are in a ________________.
   a) Creates the __________ high tides and the __________ low tides, due to
      the combined gravitational pull of the ______ and ______ on the oceans of
      Earth.

3. __________ Tides – occurs when the Sun, Moon and Earth create a ________________.
   a) Creates the __________ high tides and the __________ low tides, to due
      the gravitational pull from the sun, cancelling out the pull from the ________.

4. High Tide vs. Low Tide
   a) The period/_________ from high tide to the next high tide is on average
      ____________________.

   (i) This is a __________ change
Astronomy
In a word or sentence...

- Describe Earth’s place in the Universe.
- Identify ways that astronomers can observe the universe.
Celestial Observations

A. Celestial **Sphere**: The *apparent* surface of an imaginary **sphere** on which all celestial bodies appear to be projected.

1. It is a model of the sky; shaped like a **dome**.

2. **Celestial** Object: Any natural object in the sky. *(outside of Earth’s **atmosphere**)*
   a) Ex: Stars, **planets**, galaxies, **asteroids**
Celestial Measurement

3. **Zenith**: The highest *point* in the sky directly *above* an observer’s *head* on the Earth.
   - The point 180° opposite the zenith, directly underfoot, is the nadir.

4. **Horizon**: The imaginary *boundary* between the Earth and the sky.

5. **Altitude**: The angular *distance* of a celestial object *above* the horizon.
   - The altitude of Polaris is equal to …
Celestial Sphere

Altitude

Zenith

Horizon
Locating stars on the Celestial Sphere

Altitude
The Horizon System

1. **Azimuth**: Angular distance along the horizon; from $0^\circ$ North → **Clockwise**...
Model problems
Earth’s Rotation

1. Rotation: the cyclic spinning of an object on an axis.

   a) Earth rotates on an axis of $23 \frac{1}{2}^\circ$ from $90^\circ$.

   b) Earth makes one complete rotation in 24 hrs.
2. Evidence of Earth’s Rotation

a) **Foucault** Pendulum – an iron sphere attached to a long wire.

  - Pendulum moves around 360° due to Earth’s rotation.
Evidence of Earth’s Rotation

b) **Coriolis** Effect - the deflection of an object moving above the earth

1) Global winds are deflected to the **right** in the **Northern** Hemisphere.
2) Winds are deflected to the **left** in the **southern** hemisphere.
3. Night and Day: One **half** of Earth is experiencing darkness; while the other half is experiencing **sunlight**.
4. The Sun’s **Apparent** Motion

a) Earth rotates from **West** to **East**; in a **counter-clockwise** motion

b) **Sun** appears to move from **east** to **west**.
5. Apparent **Daily** Motion of the Stars

- **LOOKING EAST**
- **LOOKING WEST**
- **LOOKING NORTH**
- **LOOKING SOUTH**
b) The apparent daily **motion** of celestial objects **changes** when the observers **latitude** on earth **changes**

- **90°N (North Pole)**
  - No stars rise or set.

- **0° (Equator)**
  - All stars rise or set.

- **43°N (NYS)**
Apparent Daily Motion of the Stars

c) **Circumpolar** objects - Constellations or celestial objects that appear to **circle** around the North & South **poles**.

1) Never set below horizon

- **Polaris**
- **Big dipper**
- **Cassiopeia**
d) STAR TRAILS

1) The angles (°) between star trails can help us tell **how long** the shutter was open.

2) The direction of star trails vary depending on the direction the **observer** is facing.
Star Trail Photograph

NORTH

SOUTH

WEST

EAST
Cause and Effect

- Create a graphic organizer to illustrate the connections between Earth’s Rotation and daily changes we observe.
Effects of Earth’s Revolution

1. Revolution: The **orbiting** of one celestial body **around** another celestial body.

   a) Earth revolves **360°** around the sun in **365.25** days.

      1) That is a rate of ~ **1°/day** (.986…)
2. **Constellation** locations and visibility change in the sky throughout the year.

   a) Constellation: group of **stars** that form **patterns** such as; animals, legendary heroes, and mythical gods.

   1) Big dipper, Orion, Pegasus, Cassiopeia, …
Zodiac Constellations
3. Seasons - Yearly cycle
365 ¼ days

a) Causes:
- Earth revolves around the sun; in an elliptical orbit
- Earth is tilted/inclined on its axis 23 ½°
As Earth revolves, its axis **always** points in the **same** direction.

(parallelism of axis)
4. Apparent Path of the Sun

a) Sun’s path changes as latitude changes.
   1) The Sun’s path is also different for each season

NYS 43° N Latitude

Equator 0° Latitude
b) Length of **Daylight**

1) The amount of daylight **changes** with the **seasons** and with **Latitude**.

1. March 21  
   **Vernal equinox**

2. June 21  
   **Summer Solstice**

3. September 21  
   **Autumnal equinox**

4. December 21  
   **Winter Solstice**

**Tropic of Cancer**  
**Tropic of Capricorn**
## Length of daylight vs. Latitude

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</table>
Create your Own Organizer

- What observations were made to infer the Earth revolves around the sun
- How are rotation and revolution different/similar?
- What role does the Sun play in these Earth motions?
A. The **Cosmic Ladder**

1. **Earth**: a small dense rocky planet

2. **Solar system**: Earth is one of eight planets that orbit our sun.

3. Milky Way **Galaxy**: our sun is one of an estimated 180 billion stars making up this spiral galaxy.

4. **Universe**: Our Milky Way Galaxy is one of billions of galaxies in an expanding universe.
Earth’s Place in the Universe

B. Our Solar System

1. The Sun and all celestial bodies held by the Sun’s gravity and orbit the Sun.

2. Main components - Planets, moons/satellites, sun, asteroid belt, comets, meteoroids.
Planets

1) **Terrestrial** – Earth-like planets
   a) **Inner** planets: closest to the sun
   b) Relatively **small**, rocky and more **dense**
   c) **Mercury, Venus, Earth, Mars**
2) **Jovian** – Jupiter-like planets

a) Outer planets/*Gas giants*: beyond asteroid belt

b) Relatively large, composed of gases and less dense

c) Jupiter, Saturn, Uranus, Neptune

- The Sun’s Family activity
a) Geocentric Model of the Universe

- Claudius Ptolemy: 100 - 178 A.D.
  - Greek Astronomer – revolving spheres

1) **Earth** was the center of the universe.

2) All celestial objects moved around Earth in perfect circles.

3) Earth is in the center and does NOT move

4) Stars are located on a transparent sphere that rotate once a day from east to west.

5) The **Sun**, the **Moon**, and each **planet** are carried by spheres which rotate from east to west; around Earth
6) Does NOT explain
a) Movement **Foucault's** pendulum.
b) The curved path of projectiles, wind and ocean currents; **Coriolis** Effect.
b) **Helio**centric Model of the Universe

a) Nicholas **Copernicus**: 1473-1543
   - Polish Astronomer

1. The **sun** was at the **center** of the universe. Did not move
2. All the planets move in circles around the sun
3. Stars are located on a unmoving transparent sphere far from the sun
4. The moon moves in circles around the Earth
5. The Earth rotates on its axis from west to east **everyday**.
Heliocentric: Copernicus

6. Does NOT explain
   a) Cyclic changes in the apparent size of the Sun.
   b) Cyclic variations in the orbital speeds of planets

- In this model the planets orbit the sun in perfect circles
Heliocentric: Kepler

- Johannes Kepler: 1571-1630
  - German Astronomer

i. The sun is located near the center of our solar system

ii. The stars are located at various distances

iii. The orbits of the planets where “elliptical” and not circular

a) Explained why the sun’s size appeared to change, and why speed of revolution changes as planets orbit the sun.
Heliocentric

Copernicus

- Illustrate how Kepler’s model is different from Copernicus’
- Choose a planet characteristic from the Solar System

Kepler
## Solar System Data

<table>
<thead>
<tr>
<th>Celestial Object</th>
<th>Mean Distance from Sun (million km)</th>
<th>Period of Revolution (d-dec, y-years)</th>
<th>Period of Rotation at Equator</th>
<th>Equatorial Eccentricity</th>
<th>Equatorial Diameter (km)</th>
<th>Mass (Earth = 1)</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUN</td>
<td>—</td>
<td>—</td>
<td>27 d</td>
<td>—</td>
<td>1,392,000</td>
<td>333,000.00</td>
<td>1.4</td>
</tr>
<tr>
<td>MERCURY</td>
<td>57.9</td>
<td>88 d</td>
<td>59 d</td>
<td>0.206</td>
<td>4,879</td>
<td>0.06</td>
<td>5.4</td>
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<tr>
<td>VENUS</td>
<td>108.2</td>
<td>22.7 d</td>
<td>243 d</td>
<td>0.007</td>
<td>12,104</td>
<td>0.82</td>
<td>5.2</td>
</tr>
<tr>
<td>EARTH</td>
<td>149.6</td>
<td>365.26 d</td>
<td>23 h 56 min 4 s</td>
<td>0.017</td>
<td>12,756</td>
<td>1.00</td>
<td>5.5</td>
</tr>
<tr>
<td>MARS</td>
<td>227.9</td>
<td>667 d</td>
<td>24 h 37 min 23 s</td>
<td>0.093</td>
<td>6,794</td>
<td>0.11</td>
<td>3.9</td>
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<tr>
<td>JUPITER</td>
<td>778.4</td>
<td>11.9 y</td>
<td>9 h 50 min 30 s</td>
<td>0.048</td>
<td>142,964</td>
<td>317.93</td>
<td>1.3</td>
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<tr>
<td>SATURN</td>
<td>1,426.7</td>
<td>29.5 y</td>
<td>10 h 14 min</td>
<td>0.054</td>
<td>120,536</td>
<td>95.16</td>
<td>0.7</td>
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<td>URANUS</td>
<td>2,871.0</td>
<td>84.0 y</td>
<td>17 h 14 min</td>
<td>0.047</td>
<td>51,118</td>
<td>14.54</td>
<td>1.3</td>
</tr>
<tr>
<td>NEPTUNE</td>
<td>4,498.3</td>
<td>164.8 y</td>
<td>16 h</td>
<td>0.009</td>
<td>49,528</td>
<td>17.15</td>
<td>1.8</td>
</tr>
<tr>
<td>EARTH’S MOON</td>
<td>149.6</td>
<td>27.3 d</td>
<td>27.3 d</td>
<td>0.055</td>
<td>3,476</td>
<td>0.01</td>
<td>3.3</td>
</tr>
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</table>

*Many comets exist outside the orbital plane*

<table>
<thead>
<tr>
<th>Label</th>
<th>S</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>X</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object</td>
<td>Sun</td>
<td>Mercury</td>
<td>Venus</td>
<td>Earth</td>
<td>Mars</td>
<td>ASTEROID BELT</td>
<td>Jupiter</td>
<td>Saturn</td>
<td>Uranus</td>
<td>Neptune</td>
<td>Comet</td>
</tr>
<tr>
<td>Comparable Charac.</td>
<td>*ESRT p15</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

42
Laws of Planetary Motion

a) Newton’s Laws of Gravity:

1) *All objects* possess *gravity* and will *pull* all other objects with a certain *gravitational* force.

2) The *mass* of an object determines the amount of gravitational force.

a) As mass increases, gravity increases.
Laws of Planetary Motion

3) The gravitational force between two objects changes as the distance between them changes.

a) As distance increases, gravity decreases.
Newton’s Law of Inertia

1) An object’s motion will not change unless that object is acted on by and outside force.

- **Inertia**: causes a planet to move in a straight line

- **Gravity**: pulls a planet towards the sun.

- **Stable Orbit**
Kelper’s Laws of Planetary Motion

1) Law 1: The orbital shape of each planet is an ellipse, and the sun is at one foci.
   ❖ An Ellipse: (.26)

   a) Eccentricity: a measurement of the “shape” of an ellipse.
      i. Formula: Eccentricity = \( \frac{\text{distance between foci}}{\text{length of major axis}} \)
Planetary Ellipses (Orbits)

ii. Foci \((foci)\): two fixed points in an ellipse.
   - Sun is always at one foci

iii. Major axis: the longest straight line across the center of the ellipse; cuts through the middle of two foci
Eccentricity = distance between foci ÷ length of major axis

Circle - least eccentric

E = 0.250

E = 0.500

E = 0.750

Straight line - most eccentric
Eccentricity Relationships

i. As the distance between foci increases, the eccentricity value of the ellipse moves closer to one.
   - More elliptical/eccentric
   - All planet orbits look like circles to the naked eye.

ii. Comets have very elliptical orbits
Kelper’s Laws of Planetary Motion

2) Law 2: As a planet orbits the sun, its orbital speed changes; it is fastest when it is closest to the sun.

Jan. 3rd
Maximum speed

July 4th
Minimum speed

147,000,000 km
perihelion

152,000,000 km
aphelion

a) Perihelion: the point in orbit nearest the sun
b) Aphelion: the point in orbit farthest from the sun
Kepler’s Laws of Planetary Motion

3) Law 3: The farther a particular planet is from the sun, the longer its period (rate) of revolution

- Farther planets have longer orbital paths and slower orbit speeds
<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from Sun</th>
<th>Period of Revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>36 millions of miles</td>
<td>88 days</td>
</tr>
<tr>
<td>Venus</td>
<td>67</td>
<td>224 days</td>
</tr>
<tr>
<td>Earth</td>
<td>93</td>
<td>365 ¼ days</td>
</tr>
<tr>
<td>Mars</td>
<td>142</td>
<td>687 days</td>
</tr>
<tr>
<td>Jupiter</td>
<td>484</td>
<td>11.86 years</td>
</tr>
<tr>
<td>Saturn</td>
<td>887</td>
<td>29.46 years</td>
</tr>
<tr>
<td>Uranus</td>
<td>1784</td>
<td>84.01 years</td>
</tr>
<tr>
<td>Neptune</td>
<td>2795</td>
<td>164 years</td>
</tr>
</tbody>
</table>
Building Understanding

- Look back on the planetary laws and the people who discovered them.
  - Illustrate their path of discovery and understanding.
    - You may draw or create a mind map of what their ideas and thoughts may have been
The Milky Way Galaxy

1. Our sun is one in an estimated 180 billion stars that make up the Milky Way Galaxy
2. The milky way is a **Spiral Galaxy**
   - Constellations show our location

Top View

Side View

Our Solar System
Galaxies

a) Billions of stars \textit{held together by gravity}.

- Shapes:
  1) Spiral
  2) Elliptical
  3) Irregular
1. Big Bang Theory

a) 1920’s: Edwin Hubble discovered that all galaxies were moving away from Earth and each other, and thus, the universe must be expanding.

b) This idea lead to the big bang theory that states: the universe has evolved from an explosion of matter and energy.
- Supported by background radiation detected by radio telescopes.
Future of the Universe
- Dependent on mass and gravity
- Open Universe: not enough mass
  - Not enough gravity; universe continues to expand
- Closed Universe: Enough/too much mass
  - Enough gravity to stop expansion and reverse direction
    - Resulting in the BIG CRUNCH
Energy in Space

1. **Electromagnetic** Energy: energy is transferred in space with various **waves of radiation**.
2. The Sun is a major source for weather and other changes on Earth’s Surface.

   a) **Energy** from the Sun comes in many different wavelengths

   b) Energy from the sun is called Electromagnetic radiation.
c) As wavelength increases, frequency "speed" decreases.

- ESRT’s pg 14
All matter gives off energy

THE ELECTROMAGNETIC SPECTRUM

Penetrates Earth Atmosphere?

Wavelength (meters)

- Radio: $10^3$
- Microwave: $10^{-2}$
- Infrared: $10^{-5}$
- Visible: $.5 \times 10^{-6}$
- Ultraviolet: $10^{-8}$
- X-ray: $10^{-10}$
- Gamma Ray: $10^{-12}$

About the size of...

- Buildings
- Humans
- Honey Bee
- Pinpoint
- Protozoans
- Molecules
- Atoms
- Atomic Nuclei

Frequency (Hz)

- $10^4$
- $10^8$
- $10^{12}$
- $10^{15}$
- $10^{16}$
- $10^{18}$
- $10^{20}$

Temperature of bodies emitting the wavelength (K)

- 1 K
- 100 K
- 10,000 K
- 10 Million K
3. The **Visible** Light Spectrum

a) Continuous Spectrum:
   - Unbroken **band of color**
   - Contains all wavelengths
   - Produced by:
     - Glowing solid
     - Glowing liquid
     - Glowing gas
     - Under pressure/compressed
Spectroscopic

Optical layout for a Prism Spectroscope

Spectrum from an energy saving bulb

Spectrum from a sodium vapour lamp
b. Bright Line Spectrum

1. Different *wavelengths* appear as bright *lines* at different places on the spectral field.

2. Produced by chemical *element* in the form of a glowing *gas/vapor*.

3. Each element/atom has its own *unique* bright line *spectra*.
   - Just like the human fingerprint.
Bright Line Emission Spectrum

- Hydrogen
- Lithium
- Mercury

- Hydrogen
- Helium
- Lithium
- Oxygen
Dark Line \textbf{Absorption} Spectrum

c) A continuous spectrum with dark lines

1) Dark lines show where certain \textit{wavelengths} are absorbed.
   - Same placement as bright line spectrum for specific element.

2) Produced by \textit{white light}; as it passes through a cooler \textit{gas}.

3) \textbf{Elements} in gas \textbf{absorb} certain \textit{wavelengths} that they would otherwise produce as bright lines.
Light Spectra

- High density hot matter results in a continuous spectrum.
- Hot gas produces an emission spectrum.
- Cold gas results in an absorption spectrum.
Composition of Stars

- Dark line/Absorption Spectrum of Star Light
- Bright Line Spectrum of Elements as viewed on Earth
  - (in laboratories)
Doppler Effect

4. Apparent change in wavelength of light or sound.
   a) Occurs as an object moves away or towards an observer.

   http://www.pbs.org/wgbh/nova/universe/moving.html
b) Red Shift – Blue Shift

Element X
(earth laboratory)
Red-Shift vs. Distance

1) The **amount** of “red shift” is a **result** of the **speed** at which the galaxy is moving.

2) As the distance from the Earth **increases**, the amount/degree of the red shift of a galaxy also **increases**.
Red-Shift vs. Distance

Conclusion:

3) This indicates that the **farther** away a galaxy is, the **faster** it is moving.

![The Spectrum of Sodium](image)

- On Earth
- Near Galaxy
- Distant Galaxy

Increasing Wavelength: Blue → Red
Measurement of Stars

a) Luminosity: how bright a star “shines”
   1) depends on its size and its temperature; compared to the sun.
   2) The luminosity value of the Sun = 1

b) Apparent Magnitude: a star's brightness as seen by an observer on Earth

- Absolute magnitude: Is the apparent magnitude an object would have if it were 1 AU, or 149,597,871 km away from the observer.
Structure of the Sun

- **Internal structure:**
  - Inner core
  - Radiative zone
  - Convection zone

- **Photosphere**

- **Subsurface flows**

- **Chromosphere**

- **Corona**

- **Convection Zone**

- **Core (15,000,000°C)**

- **Chromosphere**

- **Prominence**

- **Surface (5,500°C)**

- **Corona (2,000,000°C)**

- **Solar Flare (4,000,000°C)**

- **Sunspots (Cooler)**
Hertzsprung-Russel Diagram
c) Light year: the **distance** light travels in **one year**

- 6 trillion (6,000,000,000,000) miles

1) The speed of light is **186,000** (1.86 x $10^5$ mi/s)

2) We see all night stars and galaxies as they were when the light left that star.
3) When we look at distant stars and galaxies we look back in time.

a) Alpha Centauri: 4.37 light years away
   - 4.37 years old

b) Sirius:
   - 8.6 years old

c) Andromeda Galaxy
   - 2,000,000 years old
Research the life cycle of a star

- Take notes as you read

- Create an illustration or story that creatively describes the stars path through the cycle.

Life Cycle of the Sun

<table>
<thead>
<tr>
<th>Birth</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Now</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gradual warming</td>
<td>Red Giant</td>
<td>Planetary Nebula</td>
<td>White Dwarf</td>
<td>not to scale</td>
<td>Billions of Years (approx.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
The Moon

IV. The moon is a *natural satellite* of the *Earth*

- *Luna* is the Latin word for moon

1. Diameter: **3476 km**
   a) Compare to Earth: **3476 km ~ 1/4<sup>th</sup>**
      **12756 km**

2. **Gravity** - **1/6<sup>th</sup>** the gravity of Earth
   a) Smaller = *Less* mass = *less* gravitational force
Physical Properties of the Moon

3. Atmosphere - Gases escape into space due to low gravity.
   - Virtually none

4. Temperatures - the moon does not have an atmosphere to aid in heat transfer.
   a) 240°F on the lighted side
   b) -240°F on the dark side
Lunar Topography
(Surface Features)

- **Craters** are bowl-shaped depressions formed primarily as a result of the impact of meteors.
  - Copernicus, Kepler, Tycho, Ptolemaeus
Surface Features

b) **Rays**: appear as bright streaks; radiate out from **craters**.

c) **Highlands**: appear as the “**lighter areas**” on the moon’s surface

1) Consist of craters and **mountains**
   - Ex: Alps, Jura, Pryrenes, Carpathian
Lunar Topography

d) There are many more craters on the moon that on Earth because...
   1) The moon does not have an atmosphere to...
      a) Burn-up incoming meteors
      b) Cause erosion to wear them away

e) Maria: appear as the “dark areas” on the moon’s surface; once thought to be “seas.”
   1) Circular smooth/flat surfaces (plains) resulted from lava flows early in the moon formation
Maria of the Nearsides of the Moon

1. Oceanus Procellarum (Ocean of Storms)
2. Mare Imbrium (Ocean of Rains)
3. Mare Humorum (Sea of Moisture)
4. Mare Nubium (Sea of Clouds)
5. Mare Serenitatis (Sea of Serenity)
6. Mare Vaporum (Sea of Vapor)
7. Mare Tranquillitatis (Sea of Tranquility)
8. Mare Crisium (Sea of Crises)
9. Mare Fecunditatis (Sea of Fertility)
10. Mare Nectaris (Sea of Nectar)
The Moon’s Revolution

a) Period of Revolution: 1 month ~ 27.3 days

b) The moon revolves around the Earth in an elliptical orbit; the Earth is at one foci.

c) This causes the moon’s apparent diameter/size to change in a cyclic manner.
The Moon’s Rotation

a) **Near Side**: the side of the moon that always faces Earth.

1) Always faces Earth because the moon’s period of **rotation** is **equal** to its period of **revolution**
The Near Side and The Far Side of the Moon

b) **Far Side**: The side of the moon that never faces Earth.
Phases of the Moon

1. Cause: The moon’s revolution around the Earth and reflection of sunlight.

2. Moon Phases: Our Earth view of the changing illuminated parts of the moon that faces the Earth.

   a) New
   b) Crescent
   c) Quarter/Half
   d) Gibbous
   e) Full
Waxing vs. Waning
Wax on, Wane off

3. Waxing: the increasing of the moon’s visible illuminated surface; from new moon to full moon.

4. Waning: the decreasing of the moon’s visible illuminated surface; from full moon to new moon.
a. The moon orbiting Earth as viewed from space
b. Phases of the moon as viewed from Earth
c.  Eclipse - the total or partial **obstruction** of one celestial body by another

a)  **Lunar Eclipse** – when the Moon’s orbital path crosses through Earth’s shadow.

b)  **Solar Eclipse** – When the Moon’s orbital path crosses between the sun and the Earth.
Parts of an Eclipse

a) Umbra – the darkest part of an eclipse/shadow; due to lack of light

b) Penumbra - a region of partial shadow located around the umbra

Total Eclipse of the Sun
Eclipse Diagrams

From Space

Lunar Eclipse

Eclipse

NOT TO SCALE

Umbra

Penumbra

As Viewed from Earth

Full Moon

Earth’s Shadow

Solar Eclipse

NOT TO SCALE

Moon Umbra

Penumbra

Corona
The Moon and The Tides

1. Tides are the periodic **rising** and **falling** of the oceans.
   a) Caused by the **moon’s gravitational** pull
   b) Affected by Earth’s **rotation**
Spring Tides

2. Occur when the Sun, moon and Earth are in a **straight line**.
   a) Creates the **highest** high tides and the **lowest** low tides.
   ❖ Due to the combined pull of the **sun** and **moon**

Neap Tides

3. Occur when the Sun, Moon and Earth create a **90° angle**.
   a) Creates the **lowest** high tides and the **highest** low tides.
   ❖ Due to Sun’s stronger gravitational pull than the **moon**.
High tide vs. Low tide

a) The period/time from high tide to high tide is normally about **12 hours and 25 min.**

i. It is a **cyclic** change

- According to your graph:
  - Next high tide:
  - Next low tide:
Write to the Moon

❖ Write as though you are Earth
❖ You may choose the purpose of your letter
  ❖ Be sure to include
    ❖ Details of your relationship and reasons why you are writing
Group Understanding

- Make a list of ideas you thought were important in this unit

- With three of your peers
  - Compare lists and fill in gaps of information

- Combine your list with other groups
  - What information did your group not include but should have?

- From the class list create 3 questions to test your classmates understanding
References


