

Natural Systems Science

Science Inquiry and Application

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise explanations and models using logic and evidence (critical thinking).
- Recognize and analyze explanations and models.
- Communicate and support a scientific argument.

Reading Standards

Key Ideas and Details:

1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
2. Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Craft and Structure:

4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
5. Analyze the structure of the relationships among concepts in a text, including relationships among key terms.
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

Integration of Knowledge and Ideas:

7. Translate quantitative or technical information expressed in words in a

Writing Standards

Text Types and Purposes:

1. Write arguments focused on discipline-specific content.
 - a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
 - b. Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
 - c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
 - d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
 - e. Provide a concluding statement or section that follows from or supports the argument presented.
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical

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text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

8. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Range of Reading and Level of Text Complexity:

10. By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

processes.

- a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
 - b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
 - c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.
 - d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
 - e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
 - f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
3. Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In history/social studies, students must be able to incorporate narrative accounts into their analyses of individuals or events of historical import. In science and technical subjects, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations or technical work that others can replicate them and (possibly) reach the same results.

Production and Distribution of Writing:

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

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6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Research to Build and Present Knowledge:

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing:

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

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Theme <i>Natural Systems Science focuses on the interactions of the earth subsystems. Each subsystem is investigated and the human impact is emphasized.</i>	
Strand <i>Exosphere</i>	
Topic <p>This topic includes and understanding of historical advances in astronomy, Kepler’s Laws of planetary motion, Earth’s revolution and the cause of seasons, angle of the sun, moon phases and composition, and Big Bang Theory.</p>	Pacing <p>9 weeks</p>
Content Statement <ol style="list-style-type: none"> 1. <i>Define the six Earth subsystems and how they interact with one another.</i> 2. <i>Define the following astronomy terms: astronomical unit, geocentric, heliocentric, perihelion, aphelion, revolution, rotation period.</i> <p><u>Origin of the Universe and Solar System</u></p> <ol style="list-style-type: none"> 3. <i>Describe the Big Bang Theory.</i> 4. <i>List evidence to support the Big Bang Theory.</i> 5. <i>Describe the solar nebula theory.</i> 6. <i>Describe early Earth.</i> 7. <i>Estimate the age of the Earth based on geological evidence.</i> <p><u>Planets</u></p> <ol style="list-style-type: none"> 8. <i>List the 8 planets in order starting with Mercury.</i> 9. <i>Contrast the Jovian planets with the terrestrial planets.</i> <p><u>Important People</u></p> <ol style="list-style-type: none"> 10. <i>Identify the contribution that each of the following individuals made to astronomy.</i> <ol style="list-style-type: none"> a. Eratosthenes b. Nicolaus Copernicus c. Galilei d. Johannes Kepler <ul style="list-style-type: none"> • Explain Kepler’s three laws of planetary motion • Calculate $P^2 = D^3$ • Relate perihelion and aphelion to speed of revolution • Define ellipse and eccentricity e. Georges Lemaitre f. Edwin Hubble 	Content Elaborations <p>Students will revisit the Big Bang Theory and the evidence for it. The historical perspective emphasizes the changes in thought based on the advances in technology. The work of Aristotle, Eratosthenes, Copernicus, Kepler, and others is studied to emphasize the inclusion of geometry and trigonometry in science. Students will revisit the solar system. In addition, studying Kepler’s Laws will involve an understanding of ellipses, gravitational forces, revolution and period, and astronomical unit.</p> <p>Understanding the cause of the seasons results from studying sun data and investigating the angle of the sun at different times of the year. The changes in the angle of the sun and the sun’s path in the sky are also important in understanding the cause of seasons and climate.</p> <p>A study of constellations helps students understand the rotation and revolution of the Earth. In addition, studying the composition of the moon emphasizes the common origin of objects in the solar system. The phases of the moon and the effect of the moon on the tides on Earth are important concepts that help students understand the interaction of the Earth subsystems.</p>

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<p>Seasons</p> <p>11. Label the Tropic of Cancer, Equator, Tropic of Capricorn, and Arctic/Antarctic Circles on the Earth.</p> <p>12. Define the tilt of the Earth.</p> <p>13. Describe the position of the Earth around the sun at the different seasons.</p> <p>14. Describe when the Earth is closest to the sun and when it is farthest.</p> <p>15. Describe when the sun is highest in the sky (both during the day and during the year).</p> <p>16. Describe how the stars appear to move through the sky.</p> <p>Angle of the Sun</p> <p>17. Calculate the angle of the sun given a height and the length of shadow.</p> <p>18. Describe how the length of a shadow changes as the day progresses.</p> <p>The Moon</p> <p>19. Draw the phases of the moon and the orientation of the moon with the Earth and sun during the phase.</p> <p>20. Describe what happens during a solar and lunar eclipse.</p>	
<p>Content Vocabulary</p> <ul style="list-style-type: none"> • aphelion • perihelion • geocentric • heliocentric • astronomical unit • rotation • revolution • period • ellipse • eccentricity • focus/foci • red shift • nebula • lunar • solstice • equinox • circumference • telescope • diffraction 	<p>Academic Vocabulary</p> <ul style="list-style-type: none"> • theory • hypothesis • law • inference • apparent • pseudoscience • technology • abundant • characteristic • magnitude • expand • quantitative • model
<p>Formative Assessments</p> <ul style="list-style-type: none"> • Quick checks on terms and calculations 	<p>Summative Assessments</p> <ul style="list-style-type: none"> • Unit tests • Quizzes • Lab analyses

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<p>Resources</p> <ul style="list-style-type: none">• Tape measures• Rulers• Meter sticks• Graph paper• Computer with Internet access	<p>Enrichment Strategies</p> <ul style="list-style-type: none">• Students can calculate the age of the universe using Hubble's Law.• Students can elaborate on the trigonometry behind Eratosthenes' work.
<p>Integrations</p> <p>New concepts should always be connected to the previous. Since this is the first unit of the year, these concepts can be reinforced by mentioning them in the next unit. The sun's incoming radiation drives weather and climate, so the concepts from this unit carry over.</p> <p>Math: trigonometry, algebra</p> <p>Social Studies: historical information</p>	<p>Intervention Strategies</p> <p>Students with disabilities or limitations can have a reduced amount of work. Graphs can be completed for them if needed. Data can be reduced to a more manageable amount.</p>

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Theme <i>Natural Systems Science focuses on the interactions of the earth subsystems. Each subsystem is investigated and the human impact is emphasized.</i>	
Strand <i>Atmosphere</i>	
Topic This topic includes basic concepts of weather and climate and how humans are able to measure, predict, map, and prepare appropriately for changing conditions. Global climate change is also included and both historical and current data are analyzed. The effects of global climate change are investigated.	Pacing 9 weeks
Content Statement <ol style="list-style-type: none"> 1. <i>Define specific heat.</i> 2. <i>Describe how the angle of the sun affects temperature.</i> 3. <i>Compare/contrast the heat capacity of soil and water.</i> 4. <i>Define isobar.</i> 5. <i>Interpret a weather map with isobars to determine weather patterns.</i> 6. <i>Describe the weather associated with high pressure and low pressure.</i> 7. <i>Define Hadley Cell.</i> 8. <i>List the major high- and low-pressure areas around the earth.</i> 9. <i>Describe the wind pattern around a high- and low-pressure area.</i> 10. <i>List the names of the major wind patterns around the earth.</i> 11. <i>Explain the relationship between atmospheric and wind patterns and ocean currents.</i> 12. <i>Describe the temperature of ocean currents relative to the equator.</i> 	Content Elaborations The focus for this topic is on the connections and interactions between Earth's spheres (the hydrosphere, atmosphere, biosphere, and lithosphere). Both natural and human-made interactions must be studied. Weather patterns, causes and effects of weather, and weather prediction are included as well as an understanding of causes and effects of climate, global climate (including el Niño/la Niña patterns and trends), and changes in climate through Earth's history.
Content Vocabulary <ul style="list-style-type: none"> • differential heating • barometric pressure • isobars • isotherms • relative humidity • specific humidity • dew point <ul style="list-style-type: none"> • heat capacity • angle of isolation • cold/warm front • salinity • remote sensing • Hadley cell • prevailing winds 	Academic Vocabulary <ul style="list-style-type: none"> • absorption • abundant • analyze • apply • approximate • characteristic • comprised • correlate • pattern • phenomenon <ul style="list-style-type: none"> • predict • reflect • infer • imply • interpret • transfer • trend • vary • utilize

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<p>Formative Assessments</p> <ul style="list-style-type: none"> • Analysis of weather data • Predictions of upcoming weather 	<p>Summative Assessments</p> <ul style="list-style-type: none"> • Unit tests • Quizzes • Analysis of weather maps • Analysis of unknown locations based on climate data • Predictions based on interpretation of weather information • Lab analysis questions
<p>Resources</p> <ul style="list-style-type: none"> • Weather data source (weather.com, local weather station) • Satellite images • Textbooks • Online resources • Thermometers • Barometers • Psychrometers • Weather maps • Historical climate data • Ocean temperature data 	<p>Enrichment Strategies</p> <ul style="list-style-type: none"> • Students can be given data to analyze that would supplement their learning. • Students can be given individual assignments within the group that are more challenging.
<p>Integrations</p> <p>Short term weather is linked to long term climate for regions. Latitude, seasons, and angle of the sun investigated in the previous unit are tied to weather and climate.</p> <p>Math: graphing and analysis between variables</p>	<p>Intervention Strategies</p> <p>Many of the concepts covered can be modified for students with language or learning deficiencies. Modifications of vocabulary, math, and lab analyses can be incorporated. In group projects, some students can be given assignments that are not as challenging as others.</p>

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Strand <i>Lithosphere and Hydrosphere</i>	
Topic <p>Lithosphere and hydrosphere interactions are explored. Students learn to read topographic maps and satellite images as a way to study the lithosphere and analyze land usage. Students also study Earth’s resources, how they are utilized in the home and industry, and the human impact that results. Water usage, treatment, contamination, and ground water flow are studied.</p>	Pacing <p>9 weeks</p>
Content Statement <ol style="list-style-type: none"> 1. <i>Explain the theory of continental drift.</i> 2. <i>Read and interpret a topographic map.</i> <ol style="list-style-type: none"> a. Identify a steep or gentle slope. b. Identify the direction a river or stream is flowing. c. Calculate the slope of an area on a topographic map. d. List some colors used in a topographic map. 3. <i>Draw a topographic profile.</i> 4. <i>Identify colors used in a satellite image.</i> 5. <i>Define mineral.</i> 6. <i>List the 5 properties used in mineral identification.</i> 7. <i>Explain the difference between a mineral and a rock.</i> 8. <i>Explain the rock cycle.</i> 9. <i>Differentiate between igneous, sedimentary, and metamorphic rocks.</i> 10. <i>Differentiate between intrusive and extrusive igneous rocks.</i> 11. <i>Differentiate between the types and formation of sedimentary rocks.</i> 12. <i>Give examples of erosion and weathering (chemical and mechanical).</i> 13. <i>Define reclamation.</i> 14. <i>Explain the process of fracking.</i> 15. <i>Analyze the pros and cons of fracking.</i> 16. <i>Test and identify minerals and how they are a part of rocks.</i> 17. <i>Describe the movement of groundwater as a result of the porosity and permeability of Earth materials.</i> 18. <i>Explain how the groundwater contamination can go unnoticed and name some contaminants.</i> 	Content Elaborations <p>The emphasis at the high school level is to relate the chemical and physical components of minerals to the properties of the minerals. This requires extensive mineral testing, investigations, experimentation, observation, use of technology, and models/modeling. The focus must be learning the ways to research, test, and evaluate minerals, not in memorization of mineral names or types. Properties such as cleavage and hardness are connected to the chemical structure and bonding of the mineral.</p> <p>Igneous, Metamorphic, and Sedimentary Rocks</p> <ul style="list-style-type: none"> • Mafic and felsic rocks and minerals • Intrusive and extrusive igneous rocks • Fossil formation • Metamorphic • Pressure, stress, temperature, and compressional forces • Foliated (regional), non-foliated (contact) • Parent rock and degrees of metamorphism • Environmental conditions that lead to fossil fuel formation • Division of sedimentary rocks and minerals (chemical, clastic/physical, organic) • Mineral resources that are used in the home • Mining practices <p>Geologic, topographic, and aerial maps must be used to locate features. Connections between the minerals present within each type of rock and the environment formed are important.</p>

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	<p>Ground water and surface water velocities and patterns are included as the movement of water (either at the surface, in the atmosphere, or beneath the surface) can be a mode of transmission of contamination. Geomorphology and topography are helpful in determining flow patterns and pathways for contamination.</p> <p>The connections and interactions of energy and matter between Earth's spheres must be researched and investigated using actual data. The emphasis is on the interconnectedness of Earth's spheres and the understanding of the complex relationships between each, including both abiotic and biotic factors. One event, such as a petroleum release or a flood, can impact each sphere. Some impacts are long-term, others are short-term, and most are a combination of both long- and short-term.</p>
<p>Content Vocabulary</p> <ul style="list-style-type: none"> • porosity • permeability • mafic • felsic • cementing agent • streak • luster • cleavage • specific gravity • fall line • gradient • adhesion • cohesion • aquifer • extrusive • intrusive <ul style="list-style-type: none"> • igneous • metamorphic • sedimentary • mineral • rock cycle • reclamation • fracking • point source • non-point source • watershed • eutrophication • algal bloom • run-off • weathering • erosion 	<p>Academic Vocabulary</p> <ul style="list-style-type: none"> • slope • gradient • interval • analysis • identification • composition <ul style="list-style-type: none"> • compare • profile • slope • graphic • evidence
<p>Formative Assessments</p> <ul style="list-style-type: none"> • Map reading assessment • Lab questions 	<p>Summative Assessments</p> <ul style="list-style-type: none"> • Quizzes • Unit tests

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<ul style="list-style-type: none"> ● Predictions for water movement ● Discussion ● Quizzes ● Identification of minerals and rocks 	<ul style="list-style-type: none"> ● Map project ● Water resource assessment
<p>Resources</p> <ul style="list-style-type: none"> ● USGS topographic maps ● Satellite images ● USGS website ● Aerial photos of Worthington ● Current articles on local lakes ● Streams with eutrophication or other pollution problems ● Rock and mineral samples and materials for testing minerals 	<p>Enrichment Strategies</p> <ul style="list-style-type: none"> ● Students can be given more difficult samples to identify. ● Water testing of local sources. ● Attend local political action groups that are debating issues concerning water usage or quality.
<p>Integrations</p> <p>Math: calculating gradient, contour intervals, maximum and minimums</p> <p>Social Studies: political and economic considerations of resource use, demographics, economic development</p> <p>Historical analyses of Worthington, Ohio, U.S., and world populations</p>	<p>Intervention Strategies</p> <p>Students that are identified can be given a modified list of minerals and rocks to identify. Terms that are used can be available for students to reference as we work through labs, quizzes, and tests.</p>

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Strand <i>Biosphere</i>	
Topic This topic covers human populations past, present, and future and the changes in resource use that parallel the population change.	Pacing 9 weeks
Content Statement <ol style="list-style-type: none"> 1. <i>Describe the condition of the human population in the past, present, and future.</i> 2. <i>List and explain the factors that affect a population which include factors that affect birth rate and mortality rate.</i> 3. <i>Create, read, and interpret a population profile.</i> 4. <i>Describe what happens to a population that has reached carrying capacity.</i> 5. <i>Compare the energy and resource consumption of various populations.</i> 6. <i>Describe how density dependent and density independent factors affect a population.</i> 7. <i>Explain the cause and effect of population changes (endangered, extirpated, extinct, invasive species).</i> 8. <i>Calculate your human footprint.</i> 9. <i>Evaluate resource use and waste management alternatives.</i> 10. <i>Develop personal alternatives for energy consumption and resource use.</i> 11. <i>Investigate forms of energy resources and evaluate the pros and cons of each.</i> 	Content Elaborations <p>The focus for this topic is on the connections and interactions between Earth’s spheres (the hydrosphere, atmosphere, biosphere, and lithosphere). Both natural and human-made interactions must be studied. This includes an understanding of causes and effects of human activities that impact Earth’s spheres, biogeochemical cycles and patterns, the effect of abiotic and biotic factors within an ecosystem, and the understanding that each of Earth’s spheres is part of the dynamic Earth system.</p> <p>Human population growth based on historical data is studied and the impact of this type of growth on the Earth systems is examined. Differences in usage of Earth’s resources can be related to geologic and demographic data.</p> <p>The study of relevant, local problems can be a way to connect the classroom to the real world. Within Ohio, there are numerous environmental topics that can be investigated. Examples include wetland loss or mitigation, surface or ground water contamination (including sediment, chemical, or thermal contamination), acid rain, septic system or sewage overflows/failures, landfill seepage, underground storage tank/pipe releases, deforestation, invasive species, air pollution (e.g., photochemical smog or particulate matter), soil loss/erosion, or acid mine drainage.</p> <p>Renewable and nonrenewable energy resources topic investigate the effectiveness, risk, and efficiency for differing types of energy resources at a local, state, national, and global level. Nuclear and geothermal energy could be included in this topic.</p> <p>Feasibility, availability, remediation, and environmental cost are included in the extraction, storage, use, and disposal of both abiotic and biotic resources. Environmental impact can be evaluated as it pertains to both the</p>

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	<p>environmental and human risk. Examples include chemical hazards, radiation, biological hazards, toxicology, and risk analysis studies. Learning about conservation and protection of the environment also requires an understanding of laws and regulations that exist to preserve resources and reduce and/or remediate contamination, but the emphasis would be on the science behind the laws and regulations.</p> <p>Relating Earth's resources to a global scale and using technology to collect global resource data for comparative classroom study is recommended. In addition, it is important to connect the industry and the scientific community to the classroom to increase the depth of understanding. Critical thinking and problem-solving skills are important in evaluating resource use, management, and conservation. New discoveries and research are important parts of this topic.</p>
<p>Content Vocabulary</p> <ul style="list-style-type: none"> • carrying capacity • gross domestic product • per capita • density-dependent • density-independent • population profiles • logarithmic • arithmetic • fertility rate • mortality rate • replacement fertility • doubling time • sustainability • recycle • remediation • waste management • landfill • human footprint • carbon footprint • invasive species • endangered and extirpated species 	<p>Academic Vocabulary</p> <ul style="list-style-type: none"> • density • exponential • limiting • developed • developing • footprint • estimate • extrapolate • evidence • succession • polymer
<p>Formative Assessments</p> <ul style="list-style-type: none"> • Interpreting population profiles • Summarizing data for various countries 	<p>Summative Assessments</p> <ul style="list-style-type: none"> • Summarize the usefulness and practicality of proposals for alternatives • Unit tests and quizzes
<p>Resources</p> <ul style="list-style-type: none"> • Population data for various countries 	<p>Enrichment Strategies</p> <ul style="list-style-type: none"> • Apply the logistic equation for population growth

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<p>Integrations</p> <p>English: writing proposals and persuasive papers supplying data and evidence to support claim</p> <p>Math: extrapolating future populations</p> <p>Social Studies: cultural influence on reproduction, and the effect on the demographics of the population</p>	<p>Intervention Strategies</p> <p>Students can use vocabulary notes during activities and assessments. Activities can be shortened for students who need modified activities.</p>
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