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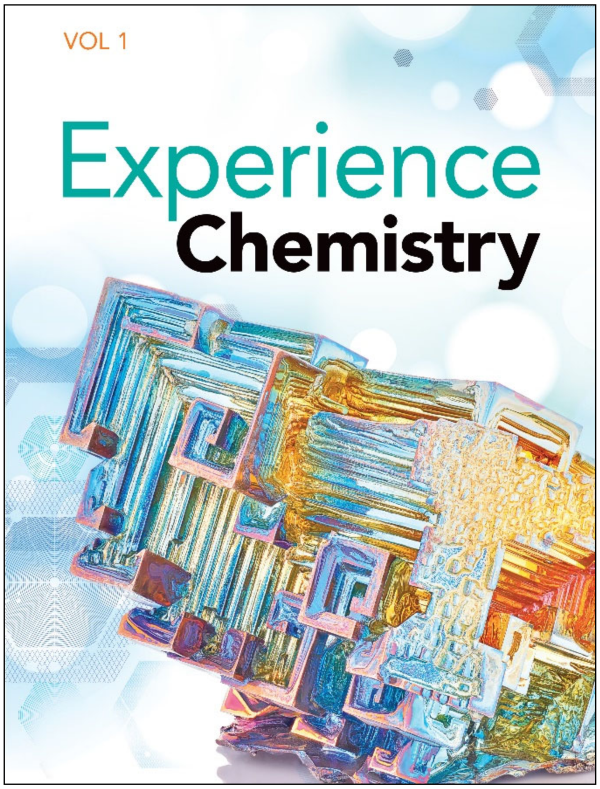

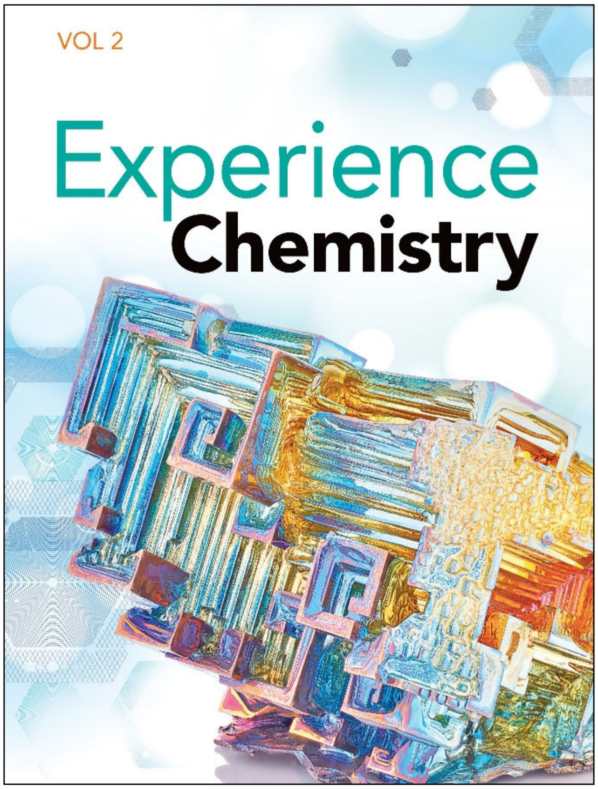

To the

Next Generation Science Standards for High School Sciences DCI Arrangement

Prepared by Savvas Learning Company, formerly Pearson K12 Learning

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#

Introduction

This document demonstrates how **Experience Chemistry ©2021** supports the Next Generation Science Standards for High School, DCI arrangement. Correlation references include the Experience Notebook (Vol. 1 and 2), Teacher Guide, and online digital assets.

Savvas Learning Company is excited to introduce **Experience Chemistry!** From climate change, water quality, and the newest energy sources, to the foods we grow and eat, your students will experience chemistry like never before. The program uses cool, weird, and amazing phenomena to engage students in 3-D science. Give students an up-close, first-hand experience they'll never forget.

Be the first to *Experience It!*

Storylines are organized around a real-world Anchoring Phenomena that sparks student curiosity, gives a purpose to learning and connects chemistry concepts through a unifying unique occurrence. Students encounter everyday phenomena through Claims-Evidence Reasoning Exercises, Authentic Readings, STEM Projects, and Engineering Performance Tasks.

Explore Phenomena with Flinn Scientific!

Experience Chemistry and Flinn Scientific partner to deliver high-quality inquiry opportunities to chemistry classrooms. Lab Experiments, Engineering Challenges, Performance Tasks, Virtual Reality Simulations, and Lab Videos by Flinn Scientific immerse students in hands-on chemistry.

Hands-On Labs
• Assign student-friendly labs focused on real-world phenomena in every learning experience.
• Customize your lessons with four versions of every lab including Open-Ended, Guided, Shortened, and Advanced.

Lab Videos
• Background videos, demo videos and summary videos engage and connect students to the phenomena, prepare students and instructors for set-up and revisit concepts before assessments.

Design Challenges and Performance Tasks
• Students mimic the real-world activities of engineers as they define and solve problems and design, test and evaluate solutions.
• Students demonstrate mastery of three-dimensional learning at the end of every Investigation with a Performance-Based assessment.

Lab Kits
• Simplify lab set-up and solution preparation with time-saving lab kits.

Virtual Reality
• Immerse your students in 360º simulations that bring chemistry to life.

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Performance Expectation HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	**Experience Notebook, Vol. 1:** The Periodic Table, 43 Connecting the Trends, 63 Activity Series, 232 Predicting the Products of Reactions, 238-239 Revisit Investigative Phenomenon, 240 Redox vs. Non-redox Reactions, 284 **Teacher Guide:** **Inquiry Labs:** Evaluate Chemical Reactions; Predict Chemical Reactions; Explore Iron Corrosion, Metal Activity **Digital Activities:** Reactivity of Metals; Cation Meets Anion **Performance Based Assessments:** Identify Evidence of Chemical Reactions; Battery Challenge **Engineering Design Challenges:** Water Purification
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• Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**Inquiry Labs:** Characteristics of Ionic Bonds; Investigate Metallic Bonds; Investigate Covalent Bonds, Intermolecular Forces; Correlate Material Properties and Bond Type; Measure the Energy of a Phase Change; Melt Ionic and Covalent Compounds; Modeling Metals, Ceramics, and Polymers; Investigate Surface Tension; Aqueous Solutions; The Thermodynamics of Hand Warmers, Compressibility, Relationships Between Gas Variables, The Ideal Gas Law, Gas Diffusion **Engineering Design Challenges:** Evaluate Metals for a Commercial Application, Abrasive Compounds, Building a Better Bike **Digital Activities:** Intermolecular Forces in Liquids, States of Matter, Tough Tools, Gas Behavior in Popping Candy **Performance-Based Assessments:** Measure Energy in Combustion Reactions, Qualitative Analysis and Chemical Bonding, Road Deicers, Identify Evidence of Chemical Reactions, Cartesian Divers
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Next Generation Science Standards High School, DCI Arrangement	**Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide**
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• Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Experience Notebook, Vol. 2:** Strong and Weak Nuclear Forces, 361-364 Revisit Investigative Phenomenon, 372 Nuclear Fission, 379 Nuclear Fusion, 380 Solar Fusion, 381 Fusion in Large Stars, 382 **Teacher Guide:** **Inquiry Labs:** Radioactive Decay **Digital Activities:** What Happens When an Atom Decays?; Energy From Nuclear Processes **Performance Based Assessments:** Natural Radiation
Science and Engineering Practices	
• Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**Experience Notebook, Vol. 2:** Radioactive Processes, 363 CCC Use Models, 379 Solar Fission, 381 SEP Use Models, 382 **Teacher Guide:** **Inquiry Labs:** Radioactive Decay; Nuclear Energy **Performance Based Assessments:** Natural Radiation
Crosscutting Concepts	
Energy and Matter	
• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	**Experience Notebook, Vol. 2:** Conservation of Mass and Energy, 373-374 CCC Energy and Matter, 380 **Teacher Guide:** **Digital Activities:** Comparing Nuclear and Chemical Reactions, Geologic Variation and Radon Levels

Next Generation Science Standards High School, DCI Arrangement	**Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide**
HS-PS2 Motion and Stability: Forces and Interactions	
Performance Expectation HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.	**Teacher Guide:** **Inquiry Labs:** Characteristics of Ionic Bonds, Characteristics of Covalent Bonds, Intermolecular Forces **Digital Activities:** Formation of Ionic Compounds, Intermolecular Forces in Liquids **Performance-Based Assessment:** Qualitative Analysis and Chemical Bonding
Disciplinary Core Ideas	
PS2.B: Types of Interactions	
• Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.	**Experience Notebook, Vol. 1:** Coulomb's Law, 52 Atomic Radius, 56-57 Ionic Bonds, 70-71 Ionic Compounds, 72-73 Revisit Investigative Phenomenon, 76 Properties of Metals, 78-79 Electronegativity and Bonding, 86-87 Geometry and Polar Molecules, 88-90 Van der Waals Forces, 91-92 Hydrogen Bonds, 93 Water and Hydrogen Bonding, 148-149 **Experience Notebook, Vol. 2:** Potential Energy, 297 Strong and Weak Nuclear Forces, 361-362 Radioactive Processes, 363-364 **Teacher Guide:** **Inquiry Labs:** Characteristics of Ionic Bonds; Investigate Covalent Bonds **Digital Activities:** Ions and Electroplating
• Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**Experience Notebook, Vol. 1:** Ionic Bonds, 70-71 Ionic Compounds, 72-73 **Experience Notebook, Vol. 2:** Potential Energy, 297 Strong and Weak Nuclear Forces, 361-362 Radioactive Processes, 363-364

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Science and Engineering Practices	
Using Mathematics and Computational Thinking	
• Use mathematical representations of phenomena to describe explanations.	**Experience Notebook, Vol. 1:** SEP Construct an Explanation, 76 SEP Use Math, 87 **Teacher Guide:** **Inquiry Labs:** Characteristics of Ionic Bonds; Investigate Covalent Bonds
Connections to Nature of Science	
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
• Theories and laws provide explanations in science.	**Experience Notebook, Vol. 1:** Coulomb's Law, 52 Ionic Compounds, 72-73 Revisit Investigative Phenomenon, 76 **Teacher Guide:** **Digital Activities:** Ions and Electroplating
• Laws are statements or descriptions of the relationships among observable phenomena.	**Experience Notebook, Vol. 1:** Coulomb's Law, 52 Ionic Compounds, 72-73 Revisit Investigative Phenomenon, 76 **Teacher Guide:** **Digital Activities:** Ions and Electroplating
Crosscutting Concepts	
Patterns	
• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	**Experience Notebook, Vol. 1:** CCC Patterns, 59 CCC Patterns, 86 **Teacher Guide:** **Digital Activities:** Ions and Electroplating; Formation of Ionic Compounds; Intermolecular Forces in Liquids **Performance Based Assessments:** Qualitative Analysis and Chemical Bonding

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Performance Expectation HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*	**Experience Notebook, Vol 1:** Properties of Metals, 78-79 **Experience Notebook, Vol. 2:** Organic Chemical Reactions, 335-336 Revisit Investigative Phenomenon, 354 **Teacher Guide:** **Inquiry Labs:** Investigate Different Hydrocarbons, Protein and Amino Acid Tests **Digital Activity:** Protein Structure and Food Design Engineering Design Challenge: Polymers: Bouncy Balls **Performance-Based Assessment:** Prepare and Characterize Biodiesel
Disciplinary Core Ideas	
PS1.A: Structure and Properties of Matter	
• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.	**Experience Notebook, Vol 1:** Ionic Compounds, 72-73 Properties of Metals, 78-79 Delocalized Electrons, 141 Ductility and Malleability, 142 Conductivity and Luster, 143 **Experience Notebook, Vol 2:** Hydrogen Structures, 314 Alkanes, 315 Isomers, 320 Halocarbons, 328 Alcohol, 329 Ethers and Amines, 330 Aldehydes and Ketones, 331 Proteins, 347-348 Structure and Energy in Lipids, 351

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PS2.B: Types of Interactions	
• Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**Experience Notebook, Vol 1:** Ionic Compounds, 72-73 Properties of Metals, 78-79 Delocalized Electrons, 141 Ductility and Malleability, 142 Conductivity and Luster, 143 **Experience Notebook, Vol 2:** Hydrogen Structures, 314 Alkanes, 315 Isomers, 320 Halocarbons, 328 Alcohol, 329 Ethers and Amines, 330 Aldehydes and Ketones, 331 Proteins, 347-348 Structure and Energy in Lipids, 351
Science and Engineering Practices	
Obtaining, Evaluating, and Communicating Information	
• Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including oral, graphical, textual and mathematical).	**Experience Notebook, Vol 2:** SEP Obtain and Communicate Information, 339 **Teacher Guide:** **Digital Activities:** Protein Structure and Food Design **Engineering Design Challenges:** Polymers: Bouncy Balls
Crosscutting Concepts	
Structure and Function	
• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.	**Experience Notebook, Vol 1:** CCC Structure and Function, 78 CCC Structure and Function, 79 **Experience Notebook, Vol 2:** CCC Structure and Function, 336 **Teacher Guide:** **Digital Activities:** Protein Structure and Food Design **Engineering Design Challenges:** Polymers: Bouncy Balls **Performance Based Assessments:** Prepare and Characterize Biodiesel

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HS-PS3 Energy	
Performance Expectation HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	**Experience Notebook, Vol. 1:** Enthalpy, 285-286 Representations of Enthalpy, 288 Sample Problem: Using Enthalpy of Reaction to Calculate Enthalpy Change, 289 Revisit Investigative Phenomenon, 290 SEP Use Mathematics, 292 Standard Enthalpy of Reaction, 293 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers; The Heat of Melting Ice **Digital Activities:** Temperature Changes in Chemical Reactions; Energy Changes in Reactions; Energy in Reactions **Performance Based Assessments:** Enthalpy of a Neutralization Reaction
Disciplinary Core Ideas	
PS3.A: Definitions of Energy	
• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Experience Notebook, Vol 1:** Interaction of Matter and Energy, 10 Chemical Reactions, 215 Energy of Reactions, 223-224 Thermochemistry, 281 Enthalpy, 284 **Experience Notebook, Vol 2:** Sample Problem: Determining Thermodynamic Favorability, 186 Energy Transformation, 297 Voltaic Cells, 298-299 **Teacher Guide:** **Inquiry Labs:** Measure the Energy of a Phase Change; The Thermodynamics of Hand Warmers; Hess's Law and the Combustion of a Metal; The Heat of Melting Ice **Digital Activities:** Energy Changes in Reactions; Energy in Reactions **Performance Based Assessments:** Enthalpy of a Neutralization Reaction **Engineering Design Challenges:** Flameless Heating Systems

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PS3.B: Conservation of Energy and Energy Transfer	
• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	**Experience Notebook, Vol 1:** Balancing Equations, 220-221 Sample Problem: Balancing a Chemical Equation, 222 Energy of Reactions, 223-224 Thermochemistry, 281 Collisions in Reactions, 282 Systems and Surroundings, 283-284 **Teacher Guide:** **Inquiry Labs:** Evaluate Chemical Reactions **Digital Activities:** Modeling Chemical Reactions; Bonds Breaking and Forming
• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Experience Notebook, Vol 1:** Chemical Reactions, 215 Balancing Equations, 220-221 Sample Problem: Balancing a Chemical Equation, 222 Energy of Reactions, 223-224 Thermochemistry, 281 Collisions in Reactions, 282 Enthalpy, 284 **Teacher Guide:** **Inquiry Labs:** Measure the Energy of a Phase Change; The Thermodynamics of Hand Warmers; Hess's Law and the Combustion of a Metal; The Heat of Melting Ice **Digital Activities:** Energy Changes in Reactions; Energy in Reactions **Performance Based Assessments:** Enthalpy of a Neutralization Reaction **Engineering Design Challenges:** Flameless Heating Systems

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• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.	**Experience Notebook, Vol 1:** Energy of Reactions, 223-224 Thermochemistry, 281 Collisions in Reactions, 282 Enthalpy, 284 Bond Enthalpy, 285-286 Activation Energy, 287 Sample Problem: Using Enthalpy of Reaction to Calculate Enthalpy Change, 289 Heat Summation, 292 Sample Problem: Calculating the Standard Enthalpy of Reaction, 295 Revisit Investigative Phenomenon, 298 Sample Problem: Using the Heat of Fusion in Phase-Change Calculations, 301 Sample Problem: Using the Heat of Vaporization in Phase-Change Calculations, 303 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers; Hess's Law and the Combustion of a Metal; The Heat of Melting Ice **Digital Activities:** Energy in Reactions; Heat of Fusion **Performance Based Assessments:** Enthalpy of a Neutralization Reaction
• The availability of energy limits what can occur in any system.	**Experience Notebook, Vol 1:** Phase Changes, 125-126 Heating a Liquid, 127 What Causes Reactions?, 225 Bond Enthalpy, 285 Activation Energy, 287 **Experience Notebook, Vol 2:** Collision Theory – A Review, 163 One-Step and Multistep Reactions, 170 Lowering Activation Energy, 171-172 Free Energy and Favorability, 181 **Teacher Guide:** **Digital Activities:** Analyze Phase Diagrams; Phase Transitions and Particle Motion; Phase Change Graphs; Enthalpy Diagrams for Phase Changes; Reaction Rates and Activation Energy; Looking Closely at Collisions and Activation Energy

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Science and Engineering Practices	
Using Mathematics and Computational Thinking	
• Create a computational model or simulation of a phenomenon, designed device, process, or system.	**Experience Notebook, Vol 1:** SEP Use Mathematics, 285 SEP Use Mathematics, 292 SEP Use a Model, 286 SEP Develop a Model, 293 **Teacher Guide:** **Inquiry Lab:** The Heat of Melting Ice **Performance-Based Assessment:** Enthalpy of a Neutralization Reaction
Crosscutting Concepts	
Systems and System Models	
• Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.	**Experience Notebook, Vol 1:** CCC Systems and System Models, 10 **Teacher Guide:** **Inquiry Lab:** The Heat of Melting Ice **Performance-Based Assessment:** Enthalpy of a Neutralization Reaction
Connections to Nature of Science	
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	
• Science assumes the universe is a vast single system in which basic laws are consistent.	**Experience Notebook, Vol 1:** Interaction of Matter and Energy, 10 Energy of Reactions, 223-224

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Performance Expectation HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).	**Experience Notebook, Vol 1:** Thermochemistry, 281 Systems and Surroundings, 283 **Experience Notebook, Vol 2:** Boyle's Law, 11 Sample Problem: Using Boyle's Law, 12 Charles's Law, 13 Absolute Zero, 15-16 Sample Problem: Using the Combined Gas Law, 20 Sample Problem: Using the Ideal Gas Law, 24 Revisit Investigative Phenomenon, 30 **Teacher Guide:** **Inquiry Labs:** Measure the Energy of a Phase Change; The Thermodynamics of Hand Warmers; Hess's Law and the Combustion of a Metal; The Heat of Melting Ice **Digital Activities:** Energy Changes in Reactions; Energy in Reactions **Performance Based Assessments:** Enthalpy of a Neutralization Reaction **Engineering Design Challenges:** Flameless Heating Systems
Disciplinary Core Ideas	
PS3.A: Definitions of Energy	
• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Experience Notebook, Vol. 1:** Interaction of Matter and Energy, 10 Chemical Reactions, 215 Energy of Reactions, 223-224 Thermochemistry, 281 Enthalpy, 284 **Experience Notebook, Vol. 2:** Sample Problem: Determining Thermodynamic Favorability, 186 Energy Transformation, 297 Voltaic Cells, 298-299 **Teacher Guide:** **Inquiry Labs:** Measure the Energy of a Phase Change; The Thermodynamics of Hand Warmers; Hess's Law and the Combustion of a Metal; The Heat of Melting Ice **Digital Activities:** Energy Changes in Reactions; Energy in Reactions **Performance Based Assessments:** Enthalpy of a Neutralization Reaction **Engineering Design Challenges:** Flameless Heating Systems

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• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Experience Notebook, Vol. 1:** Energy, 9 Thermochemistry, 281 Systems and Surroundings, 283 **Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Earth's Radiative Energy Budget, 55 Radiation: Absorption and Reradiation, 102 Energy Sources, 145-146 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers; Hess's Law and the Combustion of a Metal **Digital Activities:** Energy to Earth; Energy In and Out of Earth's Atmosphere; Flow of Energy and Greenhouse Gases **Engineering Design Challenges:** Flameless Heating System
• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	**Experience Notebook, Vol. 1:** Systems and Surroundings, 283 **Experience Notebook, Vol. 2:** Boyle's Law, 11 Charles's Law, 13 Combined Gas Law, 19 Ideal Gas Law, 23 Flow of Energy in Earth Systems, 44 Radiation: Absorption and Reradiation, 102 Incoming and Outgoing Radiation, 105-106 Radiation Penetration, 387 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers; Relationships Between Gas Variables; The Ideal Gas Law **Digital Activities:** Energy Changes in Changes of State; Model the Combined Gas Laws; Why Are There No Ideal Gases?; Energy to Earth; Energy In and Out of Earth's Atmosphere **Engineering Design Challenges:** Flameless Heating Systems

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Science and Engineering Practices	
• Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**Experience Notebook, Vol 1:** SEP Develop a Model, 281 SEP Develop a Model, 283 **Experience Notebook, Vol 2:** SEP Develop a Model, 16 SEP Develop a Model, 30 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers **Digital Activities:** Model the Combined Gas Laws
Crosscutting Concepts	
Energy and Matter	
• Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.	**Experience Notebook, Vol 1:** CCC Energy and Matter, 215 CCC Energy and Matter, 256 CCC Energy and Matter, 281, 284, 290 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers **Digital Activities:** Temperature Changes in Chemical Reactions; Energy Changes in Reactions; Bond Energy and Enthalpy; Why Are There No Ideal Gases? **Performance Based Assessments:** Enthalpy of a Neutralization Reaction

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Performance Expectation HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*	**Inquiry Labs:** The Thermodynamics of Hand Warmers, Solar Cell Technology, Build a Micro Battery **Engineering Design Challenge:** Flameless Heating Systems **Performance-Based Assessment:** Battery Challenge
Disciplinary Core Ideas	
PS3.A: Definitions of Energy	
• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Experience Notebook, Vol. 1:** Energy, 9 Thermochemistry, 281 Systems and Surroundings, 283 **Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Earth's Radiative Energy Budget, 55 Radiation: Absorption and Reradiation, 102 Energy Sources, 145-146 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers; Hess's Law and the Combustion of a Metal **Digital Activities:** Energy to Earth; Energy In and Out of Earth's Atmosphere; Flow of Energy and Greenhouse Gases **Engineering Design Challenges:** Flameless Heating Systems
PS3.D: Energy in Chemical Processes	
• Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.	**Experience Notebook, Vol. 1:** Enthalpy, 284 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers **Digital Activities:** Temperature Changes in Chemical Reactions
ETS1.A: Defining and Delimiting an Engineering Problem	
• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary)	**Experience Notebook, Vol. 2:** A Greener Vision for Chemistry, 415 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers; Solar Cell Technology

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Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
• Design, evaluate, and/or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Experience Notebook, Vol. 1:** SEP Design a Solution, 297 **Experience Notebook, Vol 2:** SEP Design a Solution, 309 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers, Solar Cell Technology, Build a Micro Battery **Engineering Design Challenge:** Flameless Heating Systems **Performance-Based Assessment:** Battery Challenge
Crosscutting Concepts	
Energy and Matter	
• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	**Experience Notebook, Vol. 1:** CCC Energy and Matter, 281 CCC Energy and Matter, 284 CCC Energy and Matter, 290 **Teacher Guide:** **Performance-Based Assessment:** Battery Challenge
Connections to Engineering, Technology, and Applications of Science	
Influence of Science, Engineering and Technology on Society and the Natural World	
• Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	**Experience Notebook, Vol. 1:** Research and Development, 405 Demand: Human Population and Consumerism, 410 **Teacher Guide** **Engineering Design Challenge:** Flameless Heating Systems **Performance-Based Assessment:** Battery Challenge

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Performance Expectation HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).	**Experience Notebook, Vol. 1:** Enthalpy of Fusion and Solidification, 300 **Experience Notebook, Vol. 2:** Entropy, 183-184 Changes in Free Energy, 185 Sample Problem: Determining Thermodynamic Favorability, 186 Strong and Weak Nuclear Forces, 361-364 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers, The Heat of Melting Ice, Supersaturation and Thermodynamics
Disciplinary Core Ideas	
PS3.B: Conservation of Energy and Energy Transfer	
• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Experience Notebook, Vol. 1:** Interaction of Matter and Energy, 10 Energy of Reactions, 223-224 Conservation of Energy, 283 **Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Biogeochemical Cycles, 45-46 **Teacher Guide:** **Inquiry Labs:** Measure the Energy of a Phase Change; The Thermodynamics of Hand Warmers; Hess's Law and the Combustion of a Metal; The Heat of Melting Ice **Digital Activities:** Energy Changes in Reactions; Energy in Reactions **Performance Based Assessments:** Enthalpy of a Neutralization Reaction **Engineering Design Challenges:** Flameless Heating Systems

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• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).	**Experience Notebook, Vol. 1:** Interaction of Matter and Energy, 10 Systems and Surroundings, 283 **Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Biogeochemical Cycles, 45-46 Feedback Tipping Points, 52 **Teacher Guide:** **Inquiry Labs:** Elements: Supersaturation and Thermodynamics **Digital Activities:** Equilibrium Shifting; Graphical Models of Entropy Changes **Engineering Design Challenges:** Use Equilibrium for a Commercial Application
PS3.D: Energy in Chemical Processes	
• Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.	**Experience Notebook, Vol. 1:** Enthalpy, 284 **Teacher Guide:** **Inquiry Labs:** The Thermodynamics of Hand Warmers **Digital Activities:** Temperature Changes in Chemical Reactions
Science and Engineering Practices	
Planning and Carrying Out Investigations	
• Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**Experience Notebook, Vol. 1:** SEP Plan an Investigation, 300 **Teacher Guide:** **Inquiry Labs:** Measure the Energy of a Phase Change, The Thermodynamics of Hand Warmers, The Heat of Melting Ice, Supersaturation and Thermodynamics **Performance Based Assessments:** Enthalpy of a Neutralization Reaction
Crosscutting Concepts	
Systems and System Models	
• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.	**Experience Notebook, Vol. 1:** Systems and Surroundings, 283 **Experience Notebook, Vol. 2:** CCC Stability and Change, 178 CCC Systems and System Models, 184

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Performance Expectation HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	**Experience Notebook, Vol. 1:** Coulomb's Law, 52 **Teacher Guide:** **Inquiry Labs:** Melt Ionic and Covalent Compounds; Modeling Metals, Ceramics, and Polymers; Investigate Surface Tension **Digital Activities:** Intermolecular Forces in Liquids **Performance Based Assessments:** Qualitative Analysis and Chemical Bonding
Disciplinary Core Ideas	
PS3.C: Relationship Between Energy and Forces	
• When two objects interacting through a field change relative position, the energy stored in the field is changed.	**Experience Notebook, Vol. 1:** Ionic Compounds, 72-73 Properties of Metals, 78-79 Revisit Investigative Phenomenon, 80 Molecular Compounds, 81 Geometry and Polar Molecules, 88-90 Van der Waals Forces, 91-92
Science and Engineering Practices	
• Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**Experience Notebook, Vol. 1:** SEP Develop and Use Models, 52 SEP Compare Models, 77 SEP Develop Models, 89 SEP Develop a Model, 154 **Teacher Guide:** **Inquiry Labs:** Modeling Metals, Ceramics, and Polymers; Investigate Surface Tension
Crosscutting Concepts	
Cause and Effect	
• Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.	**Experience Notebook, Vol. 1:** CCC Cause and Effect, 71 CCC Cause and Effect, 88 **Teacher Guide:** **Inquiry Labs:** Intermolecular Forces **Digital Activities:** Ions and Electroplating; Intermolecular Forces in Liquids

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HS-PS4 Waves and Their applications in Technologies for Information Transfer	
Performance Expectation HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 The Standard Model, 359-361 Radiation Penetration Depths, 387 **Teacher Guide:** **Inquiry Labs:** How Sunscreen Protects Us from Radiation **Digital Activities:** Ionizing Radiation Hazards; Energy In and Out of Earth's Atmosphere
Disciplinary Core Ideas	
PS4.A: Wave Properties	
• The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Experience Notebook, Vol. 2:** Surface Radiation Feedbacks, 72-73 Radiation Penetration Depths, 387 **Teacher Guide:** **Inquiry Labs:** How Sunscreen Protects Us from Radiation **Digital Activities:** Ionizing Radiation Hazards; Energy In and Out of Earth's Atmosphere
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
• Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Experience Notebook, Vol. 2:** SEP Design Your Solution, 391 **Teacher Guide:** **Inquiry Labs:** How Sunscreen Protects Us from Radiation **Digital Activities:** Energy In and Out of Earth's Atmosphere
Crosscutting Concepts	
Cause and Effect	
• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Experience Notebook, Vol. 2:** SEP Design Your Solution, 391 **Teacher Guide:** **Inquiry Labs:** How Sunscreen Protects Us from Radiation **Digital Activities:** Ionizing Radiation Hazards; Energy In and Out of Earth's Atmosphere

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Life Science	
HS-LS1 From Molecules to Organisms: Structures and Properties	
Performance Expectation HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.	**Experience Notebook, Vol. 2:** Organic Chemistry, 311 Energy from Carbohydrates, 344 Revisit Investigative Phenomenon, 354 **Teacher Guide:** **Digital Activities:** Sugar, Starch, and Glycogen; Energy Densities of Foods
Disciplinary Core Ideas	
LS1.C: Organization for Matter and Energy Flow in Organisms	
• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	**Experience Notebook, Vol. 2:** Energy from Carbohydrates, 344 Revisit Investigative Phenomenon, 354 **Teacher Guide:** **Digital Activities:** Sugar, Starch, and Glycogen; Energy Densities of Foods **Performance-Based Assessment:** Prepare and Characterize Biodiesel
• As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	**Experience Notebook, Vol. 2:** Organic Chemistry, 311 Energy from Carbohydrates, 344 Revisit Investigative Phenomenon, 354 **Teacher Guide:** **Digital Activities:** Sugar, Starch, and Glycogen; Energy Densities of Foods **Performance-Based Assessment:** Prepare and Characterize Biodiesel
Science and Engineering Practices	
• Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**Experience Notebook, Vol. 2:** CCC Energy and Matter, 311 SEP Develop a Model, 354 **Teacher Guide:** **Digital Activities:** Sugar, Starch, and Glycogen; Energy Densities of Foods
Crosscutting Concepts	
Energy and Matter	
• Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.	**Experience Notebook, Vol. 2:** SEP Develop a Model, 354 **Teacher Guide:** **Digital Activities:** Sugar, Starch, and Glycogen; Energy Densities of Foods

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Next Generation Science Standards High School, DCI Arrangement	Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide
Earth and Space Science	
HS ESS1 Earth's Place in the Universe	
Performance Expectation HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.	**Experience Notebook, Vol. 2:** Long-Term Changes in Sunlight, 77 Variations in Solar Output, 89-90 **Teacher Guide:** **Digital Activity:** Energy to Earth
Disciplinary Core Ideas	
ESS1.A: The Universe and Its Stars	
• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.	**Experience Notebook, Vol. 2:** Long-Term Changes in Sunlight, 77
PS3.D: Energy in Chemical Processes and Everyday Life	
• Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary)	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Earth's Radiative Energy Budget, 55-56 Long Term Changes in Sunlight, 77 Solar Fusion, 381 Fusion in Large Stars, 382 **Teacher Guide:** **Digital Activities:** Energy to Earth; Comparing Nuclear and Chemical Reactions
Science and Engineering Practices	
Developing and Using Models	
• Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**Experience Notebook, Vol. 2:** Radioactive Processes, 363 SEP Develop Models, 365 CCC Use Models, 379 SEP Use Models, 282
Crosscutting Concepts	
Scale, Proportion, and Quantity	
• The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.	**Experience Notebook, Vol. 2:** CCC Scale, Proportion, and Quantity, 374 CCC Scale, Proportion, and Quantity, 384 **Teacher Guide** **Digital Activities:** Energy to Earth; Comparing Nuclear and Chemical Reactions

Next Generation Science Standards High School, DCI Arrangement	Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide
Performance Expectation HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.	**Experience Notebook, Vol. 2:** Mass and Energy at the Big Bang, 376-377 Star Life-Cycle, 385-386 **Teacher Guide:** **Digital Activities:** The Composition of Stars
Disciplinary Core Ideas	
ESS1.A: The Universe and Its Stars	
• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**Experience Notebook, Vol. 1:** Atomic Emission Spectra, 22-23 **Experience Notebook, Vol. 2:** Nucleosynthesis, 383-384 Star Life-Cycle, 385-386 **Teacher Guide:** **Inquiry Labs:** Evaluate Atomic Spectra **Digital Activities:** The Composition of Stars
• The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non- stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.	**Experience Notebook, Vol. 2:** Mass and Energy at the Big Bang, 376-377 Nucleosynthesis, 383-384 **Teacher Guide:** **Digital Activities:** The Composition of Stars
• Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**Experience Notebook, Vol. 2:** Fusion in Large Stars, 382 Nucleosynthesis, 383-384 **Teacher Guide:** **Digital Activities:** Comparing Nuclear and Chemical Reactions; The Composition of Stars
PS4.B: Electromagnetic Radiation	
• Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary)	**Experience Notebook, Vol. 1:** Atomic Emission Spectra, 22-23 Revisit Investigative Phenomenon, 27 **Teacher Guide:** **Engineering Design Challenge:** Design a Spectroscope from Household Materials

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Next Generation Science Standards High School, DCI Arrangement	**Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide**
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
• Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**Experience Notebook, Vol. 2:** SEP Construct Explanations, 377 SEP Construct an Explanation, 386 **Teacher Guide:** **Digital Activities:** The Composition of Stars
Connections to Nature of Science	
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
• A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**Experience Notebook, Vol. 2:** Mass and Energy at the Big Bang, 376 **Teacher Guide:** **Digital Activities:** The Composition of Stars
Crosscutting Concepts	
Energy and Matter	
• Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems.	**Experience Notebook, Vol. 2:** CCC Energy and Matter, 380 **Teacher Guide:** **Digital Activities:** Comparing Nuclear and Chemical Reactions
Connections to Engineering, Technology, and Applications of Science	
Interdependence of Science, Engineering, and Technology	
• Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	**Experience Notebook, Vol. 2:** CCC Connect to Technology, 378 Research and Development, 405
Connections to Nature of Science	
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	
• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.	**Experience Notebook, Vol. 2:** Particle Accelerators and Transmutation, 378 **Teacher Guide** **Digital Activities:** The Composition of Stars
• Science assumes the universe is a vast single system in which basic laws are consistent.	**Experience Notebook, Vol. 2:** Big Bang, 376-377 **Teacher Guide:** **Digital Activities:** The Composition of Stars

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Next Generation Science Standards High School, DCI Arrangement	Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide
Performance Expectation HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.	**Experience Notebook, Vol. 2:** Nuclear Fusion, 380 Solar Fusion, 381 Nucleosynthesis, 383-284 Star Life-Cycle, 385-386 Revisit Investigative Phenomenon, 386 **Teacher Guide:** **Digital Activities:** The Composition of Stars
Disciplinary Core Ideas	
ESS1.A: The Universe and Its Stars	
• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**Experience Notebook, Vol. 1:** Atomic Emission Spectra, 22-23 **Experience Notebook, Vol. 2:** Nucleosynthesis, 383-384 Star Life-Cycle, 385-386 **Teacher Guide:** **Inquiry Labs:** Evaluate Atomic Spectra **Digital Activities:** The Composition of Stars
• Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**Experience Notebook, Vol. 2:** Fusion in Large Stars, 382 Nucleosynthesis, 383-384 **Teacher Guide:** **Digital Activities:** The Composition of Stars
Science and Engineering Practices	
Obtaining, Evaluating, and Communicating Information	
• Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**Experience Notebook, Vol. 2:** SEP Construct an Explanation, 386 **Teacher Guide:** **Digital Activities:** The Composition of Stars
Crosscutting Concepts	
Energy and Matter	
• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	**Experience Notebook, Vol. 2:** SEP Energy and Matter, 372 Nucleosynthesis, 383-384 **Teacher Guide:** **Digital Activities:** Comparing Nuclear and Chemical Reactions **Performance Based Assessments:** Natural Radiation

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Next Generation Science Standards **High School, DCI Arrangement**	**Experience Chemistry ©2021** **Student Experience Notebook / Teacher Guide**
Performance Expectation HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.	**Experience Notebook, Vol. 2:** Rock Cycle, 49-50 Continental Distributions and Ocean Currents, 83-84
Disciplinary Core Ideas	
ESS1.C: The History of Planet Earth	
• Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.	**Experience Notebook, Vol. 2:** Radiometric Dating of Old Materials, 371-372 **Teacher Guide** **Digital Activities:** Geologic Age and Half-Life
ESS2.B: Plate Tectonics and Large-Scale System Interactions	
• Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary)	**Experience Notebook, Vol. 2:** Rock Cycle, 49-50 Continental Distributions and Ocean Currents, 83-84
PS1.C: Nuclear Processes	
• Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)	**Experience Notebook, Vol. 2:** Radioactive Half-Lives, 365-366 Radioactive Decay Chains, 367 Radiometric Dating, 368 Sample Problem: Determining Age Using ^{14}C Radiometric Dating of Old Materials, 371-372 **Teacher Guide:** **Inquiry Labs:** Radioactive Decay **Digital Activities:** What Happens When an Atom Decays?; Geologic Age and Half-Life **Performance Based Assessments:** Natural Radiation
Science and Engineering Practices	
Engaging in Argument from Evidence	
• Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**Experience Notebook, Vol. 2:** Rock Cycle, 49-50 Continental Distributions and Ocean Currents, 83-84
Crosscutting Concepts	
Patterns	
• Empirical evidence is needed to identify patterns.	**Experience Notebook, Vol. 2:** Rock Cycle, 49-50 Continental Distributions and Ocean Currents, 83-84

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Performance Expectation HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.	**Experience Notebook, Vol. 2:** Radiometric Dating of Old Materials, 371-372 **Teacher Guide:** **Digital Activities:** Geologic Age and Half-Life
Disciplinary Core Ideas	
ESS1.C: The History of Planet Earth	
• Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.	**Experience Notebook, Vol. 2:** Rock Cycle, 49-50 Erosion and Carbon Dioxide, 82 Radiometric Dating of Old Materials, 371-372 **Teacher Guide:** **Digital Activities:** Influence of Dams on Coastal Erosion; Sampling the Past; Geologic Age and Half-Life
PS1.C: Nuclear Processes	
• Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)	**Experience Notebook, Vol. 2:** Radiometric Dating, 368 Sample Problem: Determining Age Using ^{14}C Radiometric Dating of Old Materials, 371-372 **Teacher Guide:** **Inquiry Labs:** Radioactive Decay **Digital Activities:** What Happens When an Atom Decays?; Geologic Age and Half-Life **Performance Based Assessments:** Natural Radiation
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
• Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	**Experience Notebook, Vol 2:** SEP Construct an Explanation, 372 SEP Construct an Explanation, 386 **Teacher Guide:** **Digital Activities:** Geologic Age and Half-Life; The Composition of Stars
Connections to Nature of Science	
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
• A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**Experience Notebook, Vol 2:** Radiometric Dating of Old Materials, 371-372 **Teacher Guide:** **Digital Activities:** Geologic Age and Half-Life; The Composition of Stars

Next Generation Science Standards High School, DCI Arrangement	**Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide**
• Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.	**Experience Notebook, Vol 2:** SEP Construct an Explanation, 372 **Teacher Guide:** **Digital Activities:** Geologic Age and Half-Life; The Composition of Stars
Crosscutting Concepts	
Stability and Change	
• Much of science deals with constructing explanations of how things change and how they remain stable.	**Experience Notebook, Vol 2:** CCC Stability and Change, 110 CCC Stability and Change, 357 Band of Stability, 364 SEP Use Math, 366 CCC Stability and Change, 367 **Teacher Guide:** **Digital Activities:** What Happens When an Atom Decays?; Sampling the Past; Geologic Age and Half-Life
HS-ESS2 Earth's Systems	
Performance Expectation HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50 Reinforcing and Counterbalancing Feedbacks, 51 Volcanic Activity and CO_2, 81 Erosion and Carbon Dioxide, 82 Continent Distributions and Ocean Currents, 83-84 **Teacher Guide:** **Digital Activities:** Influence of Dams on Coastal Erosion
Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems	
• Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Experience Notebook, Vol. 2:** Weather and Climate, 43 Reinforcing and Counterbalancing Feedbacks, 51 Feedback Tipping Points, 52 Climate Forcings and Feedbacks, 66-67 Evaporation Feedbacks, 68 The Ocean and Carbon Dioxide, 69 Biomass Feedbacks, 70 Methane Hydrate Feedbacks, 71 Surface Radiation Feedbacks, 72-73 Arctic Sea Ice Feedbacks, 74 Glacier Feedbacks, 75 Revisit Investigative Phenomenon, 75 Assessment, 97

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Continued:	**Continued:** **Teacher Guide:** **Inquiry Labs:** Feedback and Climate Change **Digital Activities:** Feedback and Melting Glaciers; Cold and White: A Reinforcing Feedback Loop
ESS2.B: Plate Tectonics and Large-Scale System Interactions	
• Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	**Experience Notebook, Vol 2:** Rock Cycle, 49-50 Continental Distributions and Ocean Currents, 83-84
Science and Engineering Practices	
Developing and Using Models	
• Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**Experience Notebook, Vol. 2:** SEP Develop and Use Models, 51 **Teacher Guide:** **Digital Activities:** Influence of Dams on Coastal Erosion **Performance Based Assessments:** Microhabitat in a Bottle
Crosscutting Concepts	
Stability and Change	
• Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50 Reinforcing and Counterbalancing Feedbacks, 51 Volcanic Activity and CO_2, 81 Erosion and Carbon Dioxide, 82 Continent Distributions and Ocean Currents, 83-84 **Teacher Guide:** **Digital Activities:** Influence of Dams on Coastal Erosion

Next Generation Science Standards High School, DCI Arrangement	**Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide**
Performance Expectation HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	**Experience Notebook, Vol. 2:** Weather and Climate, 43 Reinforcing and Counterbalancing Feedbacks, 51 Evaporation Feedbacks, 68 Biomass Feedbacks, 70 Methane Hydrate Feedbacks, 71 Surface Radiation Feedbacks, 72-73 Arctic Sea Ice Feedbacks, 74 Glacier Feedbacks, 75 Past Climates, 78 **Teacher Guide:** **Inquiry Labs:** Feedback and Climate Change, Energy in the Atmosphere, Observe Air Pollution, How Nature Records Changes in Climate, The pH of Seawater, Carbon Dioxide Levels in Water, The Fate of Carbonate in Acidifying Oceans **Digital Activities:** Wetlands and the Carbon Cycle, Sampling the Past, Flow of Energy and Greenhouse Gases, Glaciers on Rainier, Ocean pH, The Effect of Ocean Acidification on Shells **Performance-Based Assessments:** Microhabitat in a Bottle, Calcium Carbonate and Shell Production
Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems	
• Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Biogeochemical Cycles, 45-47 Energy and the Carbon Cycle, 47-48 Rock Cycle, 49-50 Reinforcing and Counterbalancing Feedbacks, 51 Feedback Tipping Points, 52 Human Impacts on the Earth System, 53-54 Climate Forcings and Feedbacks, 66-67 Evaporation Feedbacks, 68 The Ocean and Carbon Dioxide, 69 Biomass Feedbacks, 70 Methane Hydrate Feedbacks, 71 Surface Radiation Feedbacks, 72-73 Arctic Sea Ice Feedbacks, 74 Glacier Feedbacks, 75 Revisit Investigative Phenomenon, 75 Climate Zones: Latitude and Altitude, 76 Long Term Changes in Sunlight, 77 Past Climates, 78 Life and Carbon Dioxide, 79-80 Volcanic Activity and CO2, 81 Erosion and Carbon Dioxide, 82 Continent Distributions and Ocean Currents, 83 Ocean/Atmosphere Circulation Changes, 88

Next Generation Science Standards **High School, DCI Arrangement**	**Experience Chemistry ©2021** **Student Experience Notebook / Teacher Guide**
Continued:	**Continued:** Variations in Solar Output, 89-90 Volcanic Eruptions, 91-92 Assessment, 97 Ice Cores and Ice Ages, 107 Sea Level Change and Civilization, 108 Melting Ice and Rising Sea Levels, 109 Ice Cores and Human History, 110 Varves, Corals, and Tree Rings, 111 Medieval Climate Anomaly and Little Ice Age, 113-114 107-114 Geographic Ocean pH Variation, 232-233 Le Chatelier's Principle and Future Ocean pH, 236-237 Revisit Investigative Phenomenon, 237 Methane Hydrate, 244-245 Marine Shell Dissolution, 262-263 Disruption of Marine Ecosystems, 264-265 **Teacher Guide:** **Inquiry Labs:** Feedback and Climate Change **Digital Activities:** Feedback and Melting Glaciers; Cold and White: A Reinforcing Feedback Loop
ESS2.D: Weather and Climate	
• The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re- radiation into space.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Biogeochemical Cycles, 45-46 Earth's Radiative Energy Budget, 55-56 Climate Forcings and Feedbacks, 66-67 Evaporation Feedbacks, 68 Biomass Feedbacks, 70 Surface Radiation Feedbacks, 72-73 Arctic Sea Ice Feedbacks, 74 Long Term Changes in Sunlight, 77 Cycles within Cycles, 85-87 Variations in Solar Output, 89 Volcanic Eruptions, 91-92 Climate and Humans, 93-94 **Teacher Guide:** **Inquiry Labs:** Feedback and Climate Change; Albedo and Composition of Earth's Surface **Digital Activities:** Balance the Energy Budget; Energy to Earth; Energy In and Out of Earth's Atmosphere

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Science and Engineering Practices	
• Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**Experience Notebook, Vol. 2:** SEP Develop and Use Models, 51 SEP Analyze and Interpret Data, 67 SEP Analyze and Interpret Data, 71 SEP Analyze and Interpret Data, 74 SEP Analyze and Interpret Data, 78 SEP Analyze and Interpret Data, 80 SEP Analyze and Interpret Data, 88 SEP Analyze and Interpret Data, 94 SEP Analyze Data, 239 SEP Analyze Data, 256 SEP Interpret Data, 256 SEP Analyze Data, 257 SEP Engage in Argument, 259 **Teacher Guide:** **Inquiry Labs:** Feedback and Climate Change, Energy in the Atmosphere, Observe Air Pollution, How Nature Records Changes in Climate, The pH of Seawater, Carbon Dioxide Levels in Water, The Fate of Carbonate in Acidifying Oceans **Digital Activities:** Wetlands and the Carbon Cycle, Sampling the Past, Flow of Energy and Greenhouse Gases, Glaciers on Rainier, Ocean pH, The Effect of Ocean Acidification on Shells
Crosscutting Concepts	
Stability and Change	
• Feedback (negative or positive) can stabilize or destabilize a system.	**Experience Notebook, Vol. 2:** CCC Stability and Change, 43 CCC Stability and Change, 75 CCC Stability and Change, 77 **Teacher Guide:** **Inquiry Labs:** How Melting Ice Affects Sea Level **Performance Based Assessments:** Calcium Carbonate and Shell Production
Connections to Engineering, Technology, and Applications of Science	
Influence of Engineering, Technology, and Science on Society and the Natural World	
• New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**Experience Notebook, Vol. 2:** Energy Sources, 145-146 Transportation, 147 Infrastructure, 148 Geoengineering, 150 **Teacher Guide:** **Inquiry Labs:** How Sunscreen Protects Us from Radiation; Solar Cell Technology **Digital Activities:** Renewable Energy and Energy Storage; Reduce the Car Industry's Footprint **Engineering Design Challenges:** Design a Green Roof

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Next Generation Science Standards High School, DCI Arrangement	**Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide**
Performance Expectation HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50
Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems	
• Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50 Volcanic Activity and CO_2, 81 Erosion and Carbon Dioxide, 82
ESS2.B: Plate Tectonics and Large-Scale System Interactions	
• The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50 **Teacher Guide:** **Inquiry Labs:** Radioactive Decay **Digital Activities:** What Happens When an Atom Decays?
Science and Engineering Practices	
• Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50
Connections to Nature of Science	
Scientific Knowledge is Based on Empirical Evidence	
• Science knowledge is based on empirical evidence.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50
• Science disciplines share common rules of evidence used to evaluate explanations about natural systems.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50
• Science includes the process of coordinating patterns of evidence with current theory.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Rock Cycle, 49-50
Crosscutting Concepts	
Energy and Matter	
• Energy drives the cycling of matter within and between systems.	**Experience Notebook, Vol. 2:** CCC Energy and Matter, 46

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Connections to Engineering, Technology, and Applications of Science	
Interdependence of Science, Engineering, and Technology	
• Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	**Experience Notebook, Vol. 2:** Research and Development, 405
Performance Expectation HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	**Experience Notebook, Vol. 2:** Physical Models of Weather and Climate, 123 Models of the Twentieth Century, 126 Assessment, 155 **Teacher Guide:** **Inquiry Labs:** Albedo and Composition of Earth's Surface; How Melting Ice Affects Sea Level; Observe Air Pollution; How Nature Records Changes in Climate **Digital Activities:** Flow of Energy and Greenhouse Gases; Glaciers on Rainier **Performance Based Assessments:** Microhabitat in a Bottle
Disciplinary Core Ideas	
ESS1.B: Earth and the Solar System	
• Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary)	**Experience Notebook, Vol. 2:** Past Climates, 78 Cycles within Cycles, 85-87 The Greenhouse Effect, 100 Greenhouse Gas, 101 Radiation: Absorption and Reradiation, 102 Water and Ozone, 103 Carbon Dioxide and Methane, 104 Incoming and Outgoing Radiation, 105-106 Ice Cores and Ice Ages, 107 Sea Level Change and Civilization, 108 Melting Ice and Rising Sea Levels, 109 Ice Cores and Human History, 110 Verves, Corals, and Tree Rings, 111 Medieval Climate Change Anomaly and Little Ice Age, 113-114

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ESS2.A: Earth Materials and System	
• The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	**Experience Notebook, Vol. 2:** Long-Term Changes in Sunlight, 77 Past Climates, 78 Volcanic Activity and CO_2, 81 Erosion and Carbon Dioxide, 82 Continent Distributions and Ocean Currents, 83-84 Cycles within Cycles, 85-87 Ocean/Atmosphere Circulation Changes, 88 Variations in Solar Output, 89-90 Volcanic Eruptions, 91-92 Climate and Humans, 93-95 Revisit Investigative Phenomenon, 96 Assessment, 97 The Greenhouse Effect, 100 Greenhouse Gas, 101 Radiation: Absorption and Reradiation, 102 Water and Ozone, 103 Carbon Dioxide and Methane, 104 Incoming and Outgoing Radiation, 105-106 Ice Cores and Ice Ages, 107 Sea Level Change and Civilization, 108 Melting Ice and Rising Sea Levels, 109 Ice Cores and Human History, 110 Medieval Climate Anomaly and Little Ice Age, 113-114 Carbon Dioxide and Temperature, 115 Greenhouse Gas Release, 116 **Teacher Guide:** **Inquiry Labs:** How Melting Ice Affects Sea Level; Carbon Dioxide and Its Role in Climate; How Nature Records Changes in Climate; Human Activity and Carbon Emissions **Digital Activities:** Energy In and Out of Earth's Atmosphere; Sampling the Past; Solar Output; Flow of Energy and Greenhouse Gases; Can Volcanoes Change the Climate?

Next Generation Science Standards High School, DCI Arrangement	**Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide**
ESS2.D: Weather and Climate	
• The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re- radiation into space.	**Experience Notebook, Vol. 2:** Flow of Energy in Earth Systems, 44 Biogeochemical Cycles, 45-46 Earth's Radiative Energy Budget, 55-56 Climate Forcings and Feedbacks, 66-67 Evaporation Feedbacks, 68 Biomass Feedbacks, 70 Surface Radiation Feedbacks, 72-73 Arctic Sea Ice Feedbacks, 74 Glacier Feedbacks, 75 Cycles within Cycles, 85-87 Variations in Solar Output, 89 Volcanic Eruptions, 91-92 Climate and Humans, 93-95 **Teacher Guide:** **Inquiry Labs:** Feedback and Climate Change
• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Experience Notebook, Vol. 2:** Climate and Humans, 93-95 Greenhouse Gas, 101 Water and Ozone, 103 Carbon Dioxide and Temperature, 115 Greenhouse Gas Release, 116 Regional Temperature Change, 117 Human Population and Consumption, 118 Carbon Isotopes and Fossil Fuels, 119 Sources of Anthropogenic Carbon, 121
Science and Engineering Practices	
Developing and Using Models	
• Use a model to provide mechanistic accounts of phenomena.	**Experience Notebook, Vol. 2:** SEP Develop and Use Models, 43 SEP Develop and Use Models, 51 SEP Develop and Use Models, 56 SEP Develop and Use Models, 61 SEP Develop and Use Models, 65 SEP Develop and Use Models, 87 SEP Develop and Use Models, 116 **Teacher Guide:** **Performance Based Assessments:** Microhabitat in a Bottle

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Connections to Nature of Science	
Scientific Knowledge is Based on Empirical Evidence	
• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**Experience Notebook, Vol. 2:** SEP Engage in Argument, 106 SEP Engage in Argument, 114 SEP Engage in Argument, 122 SEP Engage in Argument, 132 SEP Engage in Argument, 142 SEP Engage in Argument from Evidence, 144 SEP Engage in Argument from Evidence, 147 SEP Engage in Argument, 154
Crosscutting Concepts	
Cause and Effect	
• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Experience Notebook, Vol. 2:** CCC Cause and Effect, 82 CCC cause and Effect, 139 **Teacher Guide:** **Inquiry Labs:** Albedo and Composition of Earth's Surface, How Melting Ice Affects Sea Level, Observe Air Pollution, How Nature Records Changes in Climate **Digital Activities:** Flow of Energy and Greenhouse Gases, Glaciers on Rainier **Performance-Based Assessment:** Microhabitat in a Bottle
Performance Expectation HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.	**Experience Notebook, Vol. 1:** Physical Properties of Materials, 111 Vapor Pressure and Boiling, 130-131 Revisit Investigative Phenomenon, 135 Water and Hydrogen Bonding, 148 Surface Tension, 149-150 Hydrogen Bonding and Boiling Point, 151 Structure Affects Properties of Ice, 152-153 Aqueous Solutions, 154-155 **Teacher Guide:** **Inquiry Labs:** Investigate Surface Tension **Digital Activities:** Water's Behavior on Earth; States of Water; The Density of Freezing Salt Water; Model Surface Tension and Polarity; Intermolecular Forces and Surface Tension in Water; Compare Intermolecular Forces in Fresh and Salt Water; Discuss the Wetland Effect

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Disciplinary Core Ideas	
ESS2.C: The Roles of Water in Earth's Surface Processes	
• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Experience Notebook, Vol. 1:** Water and Hydrogen Bonding, 148 Surface Tension, 149-150 Hydrogen Bonding and Boiling Point, 151 Structure Affects Properties of Ice, 152-153 Aqueous Solutions, 154-155 **Experience Notebook, Vol. 2:** Arctic Sea Ice Feedbacks, 74 Continent Distributions and Ocean Currents, 83-84 **Inquiry Labs:** Investigate Surface Tension **Digital Activities:** Water's Behavior on Earth; States of Water; The Density of Freezing Salt Water; Model Surface Tension and Polarity; Intermolecular Forces and Surface Tension in Water; Compare Intermolecular Forces in Fresh and Salt Water; Discuss the Wetland Effect
Science and Engineering Practices	
Planning and Carrying Out Investigations	
• Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**Teacher Guide:** **Inquiry Labs:** Investigate Surface Tension **Digital Activities:** States of Water
Crosscutting Concepts	
Structure and Function	
• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.	**Experience Notebook, Vol. 1:** CCC Structure and Function, 111 CCC Structure and Function, 155

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Performance Expectation HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.	**Experience Notebook, Vol. 2:** Energy and the Carbon Cycle, 47-48 Erosion and Carbon Dioxide, 82 Ocean-Atmosphere Carbon Dioxide Exchange, 238-239 Biogenic Carbon, 242-243 **Teacher Guide:** **Inquiry Labs:** Carbon Dioxide and Its Role in Climate, Human Activity and Carbon Emissions, Carbon Dioxide Levels in Water, Ocean Currents, The Fate of Carbonate in Acidifying Oceans Engineering **Design Challenge:** Design a Model of Ocean Acidification **Performance-Based Assessment:** Climate Change and the Carbon Cycle
Disciplinary Core Ideas	
ESS2.D: Weather and Climate	
• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.	**Experience Notebook, Vol. 2:** Energy and the Carbon Cycle, 47-48 Climate Forcings and Feedbacks, 66-67 Biomass Feedbacks, 70 Life and Carbon Dioxide, 79-80 Temperature, Pressure, and the Carbonate Compensation Depth, 240-241 **Teacher Guide:** **Digital Activities:** Carbon and the Atmosphere; Carbon Absorption **Performance Based Assessments:** Climate Change and the Carbon Cycle
• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Experience Notebook, Vol. 2:** Human Impacts on the Earth System, 53-54 Revisit Investigative Phenomenon, 54, 96 Climate and Humans, 93-95 Carbon Dioxide and Temperature, 115 Greenhouse Gas Release, 116 Regional Temperature Changes, 117 Human Population and Consumption, 118 Sources of Anthropogenic Carbon, 120-121 Revisit Investigative Phenomenon, 122 Ocean-Atmosphere Carbon Dioxide Exchange, 238-239 Temperature, Pressure, and the Carbon Compensation Depth, 240-241 Biogenic Carbon, 242-243 Disruption of Marine Ecosystems, 264-265

Next Generation Science Standards High School, DCI Arrangement	Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide
Continued:	**Continued:** **Teacher Guide:** **Inquiry Labs:** Carbon Dioxide and Its Role in Climate; Human Activity and Carbon Emissions **Digital Activities:** Bad Vibes From Greenhouse Gases; Interfering With the Carbon Cycle; Graph Climate Change **Performance Based Assessments:** Climate Change and the Carbon Cycle
Science and Engineering Practices	
Developing and Using Models	
• Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**Experience Notebook, Vol. 2:** SEP Develop and Use Models, 116 SEP Use a Model to Evaluate, 243 SEP Develop Models, 268 SEP Use Models, 269 **Teacher Guide:** **Inquiry Labs:** Carbon Dioxide and Its Role in Climate, Human Activity and Carbon Emissions, Carbon Dioxide Levels in Water, Ocean Currents, The Fate of Carbonate in Acidifying Oceans
Crosscutting Concepts	
Energy and Matter	
• The total amount of energy and matter in closed systems is conserved.	**Experience Notebook, Vol. 2:** CCC Energy and Matter, 118 CCC Energy and Matter, 119 CCC Energy and Matter, 247 CCC Energy and Matter, 259 **Inquiry Lab:** Human Activity and Carbon Emissions **Engineering Design Challenge:** Design a Model of Ocean Acidification
HS-ESS3 Earth and Human Activity	
Performance Expectation HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	**Experience Notebook, Vol. 2:** Climate and Humans, 93-95 Medieval Climate Anomaly and Little Ice Age, 113-114 Projected Changes in Extreme Weather, 131 Impact on Human Societies, 142 Demand: Human Population and Consumerism, 410 **Teacher Guide:** **Digital Activities:** Climate Change and Human Behavior; Sea Levels, Flooding, and Human Migration

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Disciplinary Core Ideas	
ESS3.A: Natural Resources	
• Resource availability has guided the development of human society.	**Experience Notebook, Vol. 2:** Spread of Diseases, 140-141 Supply: Finite Resources, 408-409 **Teacher Guide:** **Digital Activities:** Discuss the Emergence of Green Chemistry
ESS3.B: Natural Hazards	
• Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations.	**Experience Notebook, Vol. 2:** Variations in Solar Output, 89-90 Volcanic Eruptions, 91-92 Climate and Humans, 93-95 Ice Cores and Human History, 110 Medieval Climate Anomaly and Little Ice Age, 113 Famines and Wildfires, 139 Spread of Diseases, 140-141 **Teacher Guide:** **Digital Activities:** Climate Change and Human Behavior; Sea Levels, Flooding, and Human Migration
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
• Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**Teacher Guide:** **Digital Activities:** Climate Change and Human Behavior; Sea Levels, Flooding, and Human Migration
Crosscutting Concepts	
Cause and Effect	
• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Experience Notebook, Vol. 2:** CCC Cause and Effect, 139 CCC Cause and Effect, 141 **Teacher Guide:** **Digital Activities:** Climate Change and Human Behavior
Connections to Engineering, Technology, and Applications of Science	
Influence of Science, Engineering, and Technology on Society and the Natural World	
• Modern civilization depends on major technological systems.	**Experience Notebook, Vol. 2:** CCC Influence of Engineering and Technology on Society, 146

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Performance Expectation HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*	**Teacher Guide:** **Inquiry Labs:** Carbon Dioxide and Its Role in Climate, Solar Cell Technology, Investigate the Toxicity of Road Deicers, Green Chemistry Analysis of a Reaction **Digital Activity:** Paper Mill Wastewater Treatment Engineering Design Challenges: Uses and Production of Ash Water, Plastic from Biowaste **Performance-Based Assessment:** Climate Change and the Carbon Cycle
Disciplinary Core Ideas	
ESS3.A Natural Resources	
• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.	**Experience Notebook, Vol. 2:** Sources of Anthropogenic Carbon, 120-121 Solving Global Warming, 143-144 Energy Sources, 145-144 Transportation, 147 Infrastructure, 148 Carbon Capture and Sequestration, 149 Geoengineering, 150 Sustainability, 151-153 Assessment, 155
ETS1.B: Developing Possible Solutions	
• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)	**Experience Notebook, Vol. 2:** Solving Global Warming, 143-144 Energy Sources, 145-144 Transportation, 147 Infrastructure, 148 Carbon Capture and Sequestration, 149 Geoengineering, 150 Sustainability, 151-152 Assessment, 155 **Teacher Guide:** **Digital Activity:** Paper Mill Wastewater Treatment **Engineering Design Challenges:** Uses and Production of Ash Water, Plastic from Biowaste
Science and Engineering Practices	
Engaging in Argument from Evidence	
• Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).	**Experience Notebook, Vol. 2:** SEP Engage in Argument, 122 SEP Engage in Argument, 132 SEP Engage in Argument, 142 SEP Engage in Argument from Evidence, 144 SEP Engage in Argument from Evidence, 147 SEP Engage in Argument, 154 SEP Evaluate Solutions, 409 SEP Evaluate Solution, 424

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Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science	
Influence of Science, Engineering, and Technology on Society and the Natural World	
• Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	**Experience Notebook, Vol. 2:** CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 146 CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 148 CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 150 SEP Design Solutions, 152 **Performance-Based Assessment:** Climate Change and the Carbon Cycle
• Analysis of costs and benefits is a critical aspect of decisions about technology.	**Experience Notebook, Vol. 2:** CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 148 CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 150 SEP Design Solutions, 152 SEP Define Problems, 155 **Teacher Guide:** **Digital Activities:** Critique an Ecological Plan
Connections to Nature of Science	
Science Addresses Questions About the Natural and Material World	
• Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.	**Experience Notebook, Vol. 2:** CCC Science Addresses Questions About the Natural and Material World, 149
• Science knowledge indicates what can happen in natural systems — not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.	**Experience Notebook, Vol. 2:** CCC Science Addresses Questions About the Natural and Material World, 149
• Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.	**Experience Notebook, Vol. 2:** CCC Science Addresses Questions About the Natural and Material World, 149 Sustainability, 151-152

Next Generation Science Standards High School, DCI Arrangement	**Experience Chemistry ©2021 Student Experience Notebook / Teacher Guide**
Performance Expectation HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	**Experience Notebook, Vol. 2:** Solving Global Warming, 143-144 Sustainability, 151-152 A Greener Vision for Chemistry, 415-416 Sustainable Resource Management, 433 Sustainable Energy Practices, 434 Sustainable Waste Management, 435 **Teacher Guide:** **Digital Activities:** Ecological Footprint; Model Your Carbon Footprint; Critique an Ecological Plan; Discuss the Emergence of Green Chemistry; Choices When Designing Chemical Processes; Paper Mill Wastewater Treatment; Revise an Industrial Process: Plot Resource Management Scenarios and Outcomes
Disciplinary Core Ideas	
ESS3.C: Human Impacts on Earth Systems	
• The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	**Experience Notebook, Vol. 2:** Sustainability, 151-152 SEP Construct an Explanation, 415-416 Sustainable Resource Management, 433 Sustainable Energy Practices, 434 Sustainable Waste Management, 435 **Teacher Guide:** **Inquiry Labs:** How to Recycle Polylactic Acid Plastics **Digital Activities:** Model Your Carbon Footprint; Research Recycling Rates; Paper Mill Wastewater Treatment; Revise an Industrial Process
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
• Create a computational model or simulation of a phenomenon, designed device, process, or system.	**Experience Notebook, Vol. 2:** Solving Global Warming, 143-144 Sustainability, 151-152 A Greener Vision for Chemistry, 415-416 Sustainable Resource Management, 433 Sustainable Energy Practices, 434 Sustainable Waste Management, 435 **Teacher Guide:** **Digital Worksheet:** Plot Resource Management Scenarios and Outcomes
Crosscutting Concepts	
Stability and Change	
• Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	**Experience Notebook, Vol. 2:** CCC Stability and Change, 416

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Connections to Engineering, Technology, and Applications of Science	
Influence of Science, Engineering, and Technology on Society and the Natural World	
• Modern civilization depends on major technological systems.	**Experience Notebook, Vol. 2:** CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 148 Chemicals All Around Us, 404 The Chemical Industry, 405-406 Demand: Human Population and Consumerism, 410 **Teacher Guide:** **Digital Activities:** Paper Mill Wastewater Treatment, Plot Resource Management Scenarios and Outcomes
• New technologies can have deep impacts on society and the environment, including some that were not anticipated.	**Experience Notebook, Vol. 2:** CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 150 **Teacher Guide:** **Inquiry Labs:** Toxicity of Road Deicers **Digital Activities:** Reduce the Car Industry's Footprint
Connections to Nature of Science	
Science is a Human Endeavor	
• Science is a result of human endeavors, imagination, and creativity.	**Experience Notebook, Vol. 2:** Research and Development, 405 **Teacher Guide:** **Digital Activities:** Discuss the Emergence of Green Chemistry

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Performance Expectation HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*	**Experience Notebook, Vol. 2:** Geoengineering, 150 Sustainability, 151-152 Revisit Investigative Phenomenon, 154 Assessment, 155 Prevent Waste, 418 **Teacher Guide:** **Inquiry Labs:** Toxicity of Road Deicers, Uses and Production of Ash Water, How to Recycle Polylactic Acid Plastics **Digital Activities & Worksheets:** Energy-Efficient Ammonia Production, Paper Mill Wastewater Treatment, Revise an Industrial Process, Plot Resource Management Scenarios and Outcomes **Engineering Design Challenge:** Plastic from **Biowaste Performance Based Assessment:** Make the Chemistry Lab Cleaner
Disciplinary Core Ideas	
ESS3.C: Human Impacts on Earth Systems	
• Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.	**Experience Notebook, Vol. 2:** Sustainability, 151-152 A Greener Vision for Chemistry, 415-416 Sustainable Resource Management, 433 Sustainable Energy Practices, 434 Sustainable Waste Management, 435 **Teacher Guide:** **Digital Activities:** Choices When Designing Chemical Processes; Paper Mill Wastewater Treatment; Revise an Industrial Process **Engineering Design Challenges:** Plastic from Biowaste
ETS1.B: Developing Possible Solutions	
• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)	**Experience Notebook, Vol. 2:** Solving Global Warming, 143-144 Energy Sources, 145-146 Transportation, 147 Infrastructure, 148 Carbon Capture and Sequestration, 149 Geoengineering, 150 Sustainability, 151-152 Assessment, 155 **Teacher Guide:** **Digital Activities:** Paper Mill Wastewater Treatment **Engineering Design Challenges:** Plastic from Biowaste

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Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
• Design or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Experience Notebook, Vol. 2:** SEP Design Solutions, 152 SEP Engage in Argument, 154 SEP Define Problems, 155 SEP Design Solutions, 418 **Teacher Guide:** **Digital Activities & Worksheets:** Reduce the Car Industry's Footprint, Paper Mill Wastewater Treatment **Engineering Design Challenge:** Plastic from Biowaste
Crosscutting Concepts	
Stability and Change	
• Feedback (negative or positive) can stabilize or destabilize a system.	**Experience Notebook, Vol. 2:** CCC Stability and Change, 416 **Teacher Edition:** **Digital Activities:** Energy-Efficient Ammonia Production
Connections to Engineering, Technology, and Applications of Science	
Influence of Science, Engineering, and Technology on Society and the Natural World	
• Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	**Experience Notebook, Vol. 2:** CCC Influence of Engineering, Technology, and Science and the Natural World, 150 Tradeoffs and Synergies, 431 The Triple Bottom Line, 432 Recycling Materials, 433 SEP Evaluate Solutions, 434 SEP Design Solutions, 435 **Teacher Guide:** **Digital Activities:** Choices When Designing Chemical Processes; Consider Trade-Offs in Green Chemistry; Paper Mill Wastewater Treatment

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Performance Expectation HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.	**Experience Notebook, Vol. 2:** Melting Ice and Rising Sea Levels, 109 Sources of Anthropogenic Carbon, 120-121 Models of the Twentieth Century, 126 Scenarios for the Twenty-First Century, 127 Regional Temperature and Precipitation Projections, 129 Disappearing Glaciers, 136-137 **Teacher Guide:** **Inquiry Labs:** Model Climate Change with Melting Ice **Digital Activities & Worksheets:** Glaciers on Rainier, Graph Climate Change, Climate Change and Drought, Climate Change and Fire
Disciplinary Core Ideas	
ESS3.D: Global Climate Change	
• Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.	**Experience Notebook, Vol. 2:** Physical Models of Weather and Climate, 123 Earth System Models, 124 IPCC Models, 125 Scenarios for the Twenty-First Century, 127 Projected Temperatures, 128 Regional Temperature and Precipitation Projections, 129 Projected Sea Level Rise, 130 Projected Changes in Extreme Weather, 131 Solving Global Warming, 143-144 Carbon Capture and Sequestration, 149 Sustainability, 151-152 **Teacher Guide:** **Inquiry Labs:** Model Climate Change with Melting Ice **Digital Activities:** Glaciers on Rainier; Graph Climate Change; Climate Change and Drought; Climate Change and Fire; Sea Levels Rising; Sea Levels, Flooding, and Human Migration
Science and Engineering Practices	
• Analyze data using computational models in order to make valid and reliable scientific claims.	**Experience Notebook, Vol. 2:** SEP Analyze and Interpret Data, 126 SEP Analyze and Interpret Data, 128 SEP Analyze and Interpret Data, 129 SEP Analyze and Interpret Data, 131 SEP Analyze and Interpret Data, 135 SEP Analyze and Interpret Data, 140 **Teacher Guide:** **Inquiry Labs:** Model Climate Change with Melting Ice **Digital Activities:** Climate Change and Drought, Climate Change and Fire

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Connections to Nature of Science	
Scientific Investigations Use a Variety of Methods	
• Science investigations use diverse methods and do not always use the same set of procedures to obtain data.	**Experience Notebook, Vol. 2:** SEP Plan an Investigation, 54
• New technologies advance scientific knowledge.	**Experience Notebook, Vol. 2:** Earth System Models, 124 IPCC Models, 125 Scenarios for the Twenty-First Century, 127 Regional Temperature and Precipitation Projections, 129 Projected Sea Level Rise, 130 Projected Changes in Extreme Weather, 131 Revisit Investigative Phenomenon, 132
Scientific Knowledge is Based on Empirical Evidence	
• Science knowledge is based on empirical evidence.	**Experience Notebook, Vol. 2:** SEP Engage in an Argument from Evidence, 102 SEP Engage in Argument, 106 SEP Analyze and Interpret Data, 108 SEP Analyze and Interpret Data, 109 SEP Use Mathematics, 110 SEP Analyze and Interpret Data, 111 SEP Analyze and Interpret Data, 112 Sample Problem: Analyzing Graphs to Find Ancient Ocean Temperatures, 112 SEP Analyzing and Interpreting Data, 113 SEP Engage in Argument, 114 **Teacher Guide:** **Digital Activities:** Volcanic Emissions and Climate Over Time; Ice Core: Records of Climate Change; Glaciers on Rainier; Climate Change and Drought; Climate Change and Fire; Sea Levels Rising; Climate Change and the Biosphere
• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**Experience Notebook, Vol 2:** SEP Engage in Argument from Evidence, 102 SEP Engage in Argument, 106 SEP Engage in Argument, 114 SEP Engage in Argument, 122 SEP Engage in Argument, 132 SEP Engage in Argument, 142 SEP Engage in Argument from Evidence, 144 SEP Engage in Argument from Evidence, 147 SEP Engage in Argument, 154 **Teacher Guide:** **Digital Activities:** Ice Core: Records of Climate Change; Sea Levels Rising

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Crosscutting Concepts	
Stability and Change	
• Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	**Experience Notebook, Vol. 2:** CCC Stability and Change, 127 CCC Stability and Change, 130 CCC Stability and Change, 136 **Teacher Guide:** **Digital Activities:** Glaciers on Rainier; Climate Change and the Biosphere
Performance Expectation HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.	**Experience Notebook, Vol. 2:** Greenhouse Gas Release, 116 Revisit Investigative Phenomenon, 211 A Greener Vision for Chemistry, 415 Assessment, 439 **Teacher Guide:** **Inquiry Labs:** Human Activity and Carbon Emissions; Climate Change and Keeping Cool **Digital Activities:** Interfering With the Carbon Cycle; Climate Change and the Biosphere **Performance-Based Assessment:** Climate Change and the Carbon Cycle
Disciplinary Core Ideas	
ESS2.D: Weather and Climate	
• Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary)	**Experience Notebook, Vol. 2:** Carbon Dioxide and Temperature, 115 Regional Temperature Changes, 117 Earth System Models, 124 IPCC Models, 125 Scenarios for the Twenty-First Century, 127 Projected Temperatures, 128 Regional Temperature and Precipitation Projections, 129 Projected Sea Level Rise, 130 Projected Changes in Extreme Weather, 131 Droughts, 133 Extreme Precipitation, 134-135 Disappearing Glaciers, 136-137 Impact on the Biosphere, 138 Famines and Wildfires, 139 Spread of Diseases, 140-141 Impact on Human Societies, 142 **Teacher Guide:** **Inquiry Labs:** Human Activity and Carbon Emissions **Digital Activities:** Interfering with the Carbon Cycle; Climate Change and the Biosphere

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ESS3.D: Global Climate Change	
• Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Experience Notebook, Vol 2:** IPCC Models, 125 Scenarios for the Twenty-First Century, 127 Projected Temperatures, 128 Regional Temperature and Precipitation Projections, 129 Projected Sea Level Rise, 130 Projected Changes in Extreme Weather, 131 Extreme Precipitation, 134-135 Disappearing Glaciers, 136-137 Impact on the Biosphere, 138 Famines and Wildfires, 139 Spread of Diseases, 140-141 Impact on Human Societies, 142 Le Chatelier’s Principle and Future Ocean pH, 236-237 Ocean-Atmosphere Carbon Dioxide Exchange, 238-239 **Teacher Guide:** **Inquiry Labs:** Human Activity and Carbon Emissions **Digital Activities:** Interfering With the Carbon Cycle; Climate Change and the Biosphere
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
• Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.	**Experience Notebook, Vol 2:** SEP Use Mathematics and Computational Thinking, 121 SEP Use Mathematics and Computational Thinking, 138 **Teacher Guide:** **Inquiry Labs:** Human Activity and Carbon Emissions, Climate Change and Keeping Cool **Digital Worksheet:** Climate Change and the Biosphere
Crosscutting Concepts	
Systems and System Models	
• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.	**Experience Notebook, Vol. 2:** CCC Systems and System Models, 124 CCC Systems and System Models, 125 CCC Stability and Change, 127 **Teacher Guide:** **Inquiry Labs:** Human Activity and Carbon Emissions **Digital Activities:** Interfering With the Carbon Cycle; Climate Change and the Biosphere

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Engineering, Technology, and Application of Science	
HS-ETS Engineering Design	
Performance Expectation HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	**Teacher Guide:** **Inquiry Labs:** Toxicity of Road Deicers, How to Recycle Polylactic Acid Plastics **Engineering Design Challenges:** Evaluate Metals for a Commercial Application, Building a Better Bike, Water Purification, Design a Model of Ocean Acidification, Plastic from Biowaste **Performance-Based Assessment:** Prepare and Characterize Biodiesel **Problem-Based Learning:** The Chemistry of Cooking, Water as a Greenhouse Gas, Reducing Carbon Footprints, Sustainable Off-Grid Energy
Disciplinary Core Ideas	
ETS1.A: Defining and Delimiting Engineering Problems	
• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	**Experience Notebook, Vol. 2:** Solving Global Warming, 144-145 Sustainability, 151-152 Assessment, 155 Supply: Finite Resources, 408-409 Demand: Human Population and Consumerism, 410 Environmental Impacts of Chemical Industries, 412 Chemical Disasters, 414 A Greener Vision for Chemistry, 415 **Teacher Guide:** **Engineering Design Challenges:** Evaluate Metals for a Commercial Application; Building a Better Bike; Water Purification; Design a Model of Ocean Acidification **Problem-Based Learning:** The Chemistry of Cooking and the Properties of Baked Goods; Water as a Greenhouse Gas; Reducing Carbon Footprints
• Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	**Experience Notebook, Vol. 2:** Human Impacts on the Earth System, 53-54 Climate and Humans, 93-95 Sources of Anthropogenic Carbon, 120-121 Famines and Wildfires, 139 Spread of Diseases, 140-141 Impact of Human Societies, 142 Challenges for Chemical Production, 407 Supply: Finite Resources, 408-409

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Science and Engineering Practices	
• Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**Experience Notebook, Vol. 1:** SEP Define a Problem, 147 SEP Define Problems, 171 SEP Define a Problem, 203 SEP Define a Problem, 248 SEP Define a Problem, 274 **Experience Notebook, Vol. 2:** SEP Define Problems, 155 **Teacher Guide:** **Problem-Based Learning:** Water as a Greenhouse Gas, Reducing Carbon Footprints, Sustainable Off-Grid Energy
Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science	
Influence of Science, Engineering, and Technology on Society and the Natural World	
• New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**Volume 2** **Investigation 11** **SN:** CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 150 **Digital Activities:** Reduce the Car Industry's Footprint
Performance Expectation HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	**Teacher's Guide:** **Inquiry Lab:** How to Recycle Polylactic Acid Plastics **Engineering Design Challenges:** Growing Crystals in Gel, Abrasive Compounds, Building a Better Bike, An Empirical Formula Challenge, Water Purification, Flameless Heating Systems, Use Equilibrium for a Commercial Application, Design a Model of Ocean Acidification, Uses and Production of Ash Water, Plastic from Biowaste **Performance-Based Assessment:** Prepare and Characterize Biodiesel

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Disciplinary Core Ideas	
ETS1.C: Optimizing the Design Solution	
• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.	**Experience Notebook, Vol. 2:** Energy Sources, 145-146 Transportation, 147 Infrastructure, 148 Carbon Capture and Sequestration, 149 Geoengineering, 150 Sustainability, 151-152 **Teacher Guide:** **Engineering Design Challenges:** Building a Spectroscope from Household Materials; Growing Crystals in Gels; Evaluate Metals for a Commercial Application; Abrasive Compounds; An Empirical Formula Challenge
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
• Design a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Experience Notebook, Vol. 1:** SEP Design a Solution, 160, SEP Design a Solution, 170 SEP Define Problems, 171 SEP Design a Solution, 297 **Experience Notebook, Vol. 2:** SEP Design Solutions, 68 SEP Design a Solution, 70 SEP Design Solutions, 152 SEP Design Your Solution, 265 **Teacher Guide:** **Engineering Design Challenges:** Building a Spectroscope from Household Materials; Growing Crystals in Gel; Abrasive Compounds; Building a Better Bike; An Empirical Formula Challenge; Water Purification; Flameless Heating Systems; Use Equilibrium for a Commercial Application; Design a Model of Ocean Acidification

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Performance Expectation HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	**Teacher Guide:** **Inquiry Lab:** How to Recycle Polylactic Acid Plastics **Engineering Design Challenges:** Evaluate Metals for a Commercial Application, Abrasive Compounds, Building a Better Bike, Flameless Heating Systems, Uses and Production of Ash Water, Plastic from Biowaste **Performance-Based Assessment:** Prepare and Characterize Biodiesel
Disciplinary Core Ideas	
ETS1.B: Developing Possible Solutions	
• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	**Experience Notebook, Vol. 2:** Human Impacts on the Earth System, 53-54 Climate and Humans, 93-95 Sources of Anthropogenic Carbon, 120-121 Impact on the Biosphere, 138-139 Climate Change, Migration, and Conflict, 141 Sustainability, 151-152 The Chemical Industry, 405-406 Challenges for Chemical Production, 407 Supply: Finite Resource, 408-409 Renewable Feedstocks, 424-425
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
• Evaluate a solution to a complex real- world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Experience Notebook, Vol. 1:** SEP Design a Solution, 147 SEP Design a Solution, 170 SEP Define a Problem, 203 SEP Define a Problem, 248 SEP Define a Problem, 274 **Experience Notebook, Vol. 2:** SEP Define Problems, 155 SEP Evaluate Solutions, 409 SEP Evaluate Solutions, 424 **Teacher Guide:** **Performance-Based Assessment:** Prepare and Characterize Biodiesel **Problem-Based Learning:** Sustainable Off-Grid Energy

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Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science	
Influence of Science, Engineering, and Technology on Society and the Natural World	
• New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**Experience Notebook, Vol. 2:** CCC Influence of Engineering and Technology on Society, 146 CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 148 CCC Influence of Engineering, Technology, and Science on Society and the Natural World, 150 **Teacher Guide:** Engineering Design Challenges: Uses and Production of Ash Water, Plastic from Biowaste
Performance Expectation HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	**Teacher Guide:** **Digital Activities & Worksheets:** Model Your Carbon Footprint, Paper Mill Wastewater Treatment, Plot Resource Management Scenarios and Outcomes **Problem-Based Learning:** Reducing Carbon Footprints, Sustainable Off-Grid Energy
Disciplinary Core Ideas	
ETS1.B: Developing Possible Solutions	
• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	**Experience Notebook, Vol. 2:** Earth System Models, 124 IPCC Models, 125 Scenarios for the Twenty-First Century, 127 Projected Temperatures, 128 Projected Sea Level Rise, 130 Projected Changes in Extreme Weather, 131 Revisit Investigative Phenomenon, 132 **Teacher Guide:** **Digital Activities & Worksheets:** Model Your Carbon Footprint, Paper Mill Wastewater Treatment, Plot Resource Management Scenarios and Outcomes

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Science and Engineering Practices	
Using Mathematics and Computational Thinking	
• Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**Experience Notebook, Vol. 2:** SEP Use Mathematics, 110 SEP Use Mathematics and Computational Thinking, 121 Model Parameterization, 124 CESM Image, 125 Modeling Global Temperature History, 126 SEP Analyze and Interpret Data, 128 SEP Use Mathematics and Computational Thinking, 138 **Teacher Guide:** **Digital Activities & Worksheets:** Model Your Carbon Footprint, Paper Mill Wastewater Treatment, Plot Resource Management Scenarios and Outcomes
Crosscutting Concepts	
Systems and System Models	
• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.	**Experience Notebook, Vol. 2:** Earth System Models, 124 IPCC Models, 125 Models of the Twentieth Century, 126 Scenarios for the Twenty-First Century, 127 Projected Temperatures, 128 **Teacher Guide:** **Digital Activities:** Model Your Carbon Footprint **Engineering Design Challenges:** Design a Model of Ocean Acidification