Bloomfield Public Schools
Bloomfield, New Jersey 07003

Curriculum Guide

Astronomy CP
Grades 11-12

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Conforms to the Next Generation Science Standards and NJSLS Standards

Board Approved: September 12, 2017

Astronomy - CP
Grades 11-12

Introduction: In Astronomy, students will study the universe as they cover the following topics: history of astronomy, gravity and motion, planets, stars, galaxies and the structure of the universe. This course places an emphasis on how astronomers gather information about distant objects without leaving the Earth.

This document is a tool that will provide an overview as to what to teach, when to teach it, and how to assess student progress. As well, with considerations made for altered pacing, modifications, and accommodations; this document is to be utilized for all students enrolled in this course, regardless of ability level, native language, or classification. It is meant to be a dynamic tool that we, as educators, will revise and modify as it is used during the course of the school year.

This curriculum is aligned with the *Next Generation Science Standards*, the *New Jersey Student Learning Standards for English Language Arts & Literacy in Science, Mathematics, and Technology.*

Pacing: The Astronomy course focuses on four topics:

Unit 1: Astronomy and the Universe
Unit 2: Our Planetary Systems
Unit 3: Stars and Stellar Evolution
Unit 4: Galaxies and Cosmology

Resources: Electronic and text resources are listed in each unit. Teachers will be able to access the curriculum document on the district website.

Textbook: *Astronomy Today*, E. Chaisson and S. McMillan: 2014

Established Goals: New Jersey Student Learning Standards

Science: http://www.nextgenscience.org/next-generation-science-standards

Math Standards: http://www.state.nj.us/education/aps/ccs/math/

ELA Standards: http://www.state.nj.us/education/aps/ccs/lal/

Technology: http://www.state.nj.us/education/cccs/2014/tech/

Modifications:
• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Unit #: 1	**Unit Name:** Astronomy and the Universe	**Unit Length:** 35 days

ESSENTIAL QUESTIONS:	What is our place in the universe? Why is it important to understand the history of astronomy?	
#	**STUDENT LEARNING OBJECTIVES (SLO)**	**Corresponding DCIs and PEs**
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 that eventually reaches Earth in the form of radiation.** [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [*Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]*	**HS-ESS1-1**
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.** [Clarification Statement: Emphasis is on the astronomical evidence of the redshift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (¾ hydrogen and ¼ helium).]	**HS-ESS1-2**
3	**Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [*Assessment Boundary:*	**HS-ESS1-4**

	Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]	

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HSESS1-1) **Using Mathematical and Computational Thinking** Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.	**ESS1.B: Earth and the Solar System** • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4) **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 to HS-ESS1-1) **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 to HS-ESS1-2)	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1) • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4) **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. (HS-ESS1-2) --- **Connection 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

• Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • 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. (HS-ESS1-2) --- **Connections to Nature of Science**		development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HSESS1-2),(HS-ESS1-4) --- **Connection 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. (HS-ESS12) • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2

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. (HS-ESS1-2)		

Connections to other DCIs in this grade-band:

HS.PS1.A (HS-ESS1-2), (HS-ESS1-3); **HS.PS1.C** (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-**3); HS.PS2.B (**HS-ESS1-4**); HS.PS3.A (**HS-ESS1-1),(HS-ESS1-2); **HS.PS3.B** (HS-ESS1-2); **HS.PS4.A** (HS-ESS1-2)

Articulation of DCIs across grade-bands:

MS.PS1.A (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3); **MS.PS2.A** (HS-ESS1-4); **MS.PS2.B** (HS-ESS1-4); **MS.PS4.B** (HS-ESS1-1),(HS-ESS1-2); **MS.ESS1.A** (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4); **MS.ESS1.B** (HS-ESS1-4); **MS.ESS2.A** (HS-ESS1-1); **MS.ESS2.D** (HS-ESS1-1)

ELA and Math Standards Connections:

ELA:

RST.11-12.1 Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-ESS1-1),(HS-ESS1-2)
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2), (HSESS1-3)
SL.11-12.4. Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. (HS-ESS1-3)

MATH:
MP.2 Reason abstractly and quantitatively. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4)
MP.4 Model with mathematics. (HS-ESS1-1),(HS-ESS1-4) HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2) ,(HS-ESS1-4)
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1),(HS-ESS1-2), (HS-ESS1-4)
HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HSESS1-1),(HS-ESS1-2),(HS-ESS1-4)

HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
Technology & Career Standards: **8.1 Educational Technology:** All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge. **Career Ready Practices:** 1-12

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**
Gamma Ultraviolet Infrared Laws Solstice Eclipses Equinox Constellation Astronomical Unit Telescope Electromagnetic Radiation Spectroscope Absorption Kirchhoff's Reflecting Refracting Photon Proton Radio Doppler Effect	Direct vs. Indirect Observation Chemical Properties Resolution Physical Properties Density Objectives Hypothesis Magnification Scientific Law & Theory Angular Measurement Decipher Motion Cyclic Scale	*Astronomy Today* by Chaisson and McMillan Chapter 1- Charting the Heavens: The Foundations of Astronomy Chapter 2- The Copernican Revolution: The Birth of Modern Science Chapter 3- Radiation: Information from the Cosmos Chapter 4- Spectroscopy: The Inner Workings of Atoms

Retrograde Motion Eccentricity Kepler's Laws of Motion Heliocentric Geocentric	Interval Spectrum Diameter Analytical Analysis Conceptual Model	Chapter 5- Telescopes: The Tools of Astronomy Online access to internet websites and readings required are below.

THE 5 "E"s	**Examples of Learning Activities for the specified "E"**	**SLO's and Engineering Practices**
ENGAGE	**Examples of Engaging Activities:**	
	"Shoot the Stars" Virtual Lab on the Doppler Effect	2/Asking Questions and defining Problems
	Temperature and Composition of Stars Video	3
	Early Universe Video and Article Reading	1/ Engaging in Argument from Evidence
EXPLORE	**Examples of Exploring Activities:**	
	Measuring Distances in Space Activity # 1 (Discovery Education)	3/Using Mathematics and Computational Thinking
	Sunglasses / Build a Better Product (Discovery Education)	2/Developing and Using Models
	Technology and Electromagnetic Spectrum: 1 (Discovery Education)	2
	Time travel to the edge of the universe and back	2/Obtaining, Evaluating and Communicating Information
EXPLAIN	**Examples of Explaining Activities:**	
	Measuring Distances in Space: 2 (Discovery Education)	3
	A Matter of Geometry Activity (Discovery Education)	2/Using Mathematics and Computational Thinking

	H - R Diagram Plotting and Graphing Activity	1/Using Mathematics and Computational Thinking
	Phases of the Moon Investigation	3/Planning and Carrying Out Investigations
	Astropedia Readings with Teacher Based Questions	1,2,3
ELABORATE	**Examples of Elaborating Activities:**	
	Structure of the Milky Way Galaxy	3
	Technology and Electromagnetic Spectrum: 2 (Discovery Education)	2/Using Mathematics and Computational Thinking
	Star Life Cycle WebQuest	1, 3
	Eclipses - 3D Lab	3/Developing and Using Models
EVALUATE	**Examples of Evaluating Activities:**	
	Modeling Kepler's Lab of Planetary Motion (discovery education)	4/Using Mathematics and Computational Thinking
	Technology and Electromagnetic Spectrum Assessment (Discovery education)	2
	X-Ray Spectroscopy Lab Investigation	2/Obtaining, Evaluating and Communicating Information
	Elements in Stars, Colored Code for Composition as It Relates to the Periodic Table	2, 3/Constructing Explanations and Designing Solutions

Unit #: 2	**Unit Name:** Our Planetary System	**Unit Length:** 35 days

ESSENTIAL QUESTIONS:

What proof do we have that the moon was once part of our Earth?
What happened before the birth of the universe?
Will there be an end to the universe?

#	STUDENT LEARNING OBJECTIVES (SLO)	Corresponding DCIs and PEs
1	**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.** [Clarification Statement: Emphasis is on the astronomical evidence of the redshift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (¾ hydrogen and ¼ helium).]	HS-ESS1-2
2	**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. [**Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).]	HS-ESS1-5
3	**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.** [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]	HS-ESS1-6
4	**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.** [Clarification Statement: Emphasis is	HS-ESS2-1

	on how the appearance of land features (such as mountains, valleys, and plateaus) and seafloor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.]	

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also	**ESS1.A: The Universe and Its 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. (HS-ESS1-2) **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. (HS-ESS1-5) • 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,	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1) --- **Connection 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. (HS-ESS1-2) • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

come from current scientific or historical episodes in science. • Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5) --- **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. (HS-ESS1-6) • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6	have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **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 to HS-ESS1-5) ,(HS-ESS2-1) • Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-ESS2-1)	

Connections to other DCIs in this grade-band: HS.PS1.A (HS-ESS1-2), (HS-ESS1-3); **HS.PS1.C** (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-**3); HS.PS2.B (**HS-ESS1-4**); HS.PS3.A (**HS-ESS1-1),(HS-ESS1-2); **HS.PS3.B** (HS-ESS1-2); **HS.PS4.A** (HS-ESS1-2)
HS.PS2.A (HS-ESS1-6); **HS.PS2.B** (HS-ESS1-6**)**, (HS-ESS2-1); **HS.PS3.B (**HS-ESS1-5**); HS. ESS2.A** (HS-ESS1-5)

Articulation of DCIs across grade-bands: MS.PS1.A (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3); **MS.PS2.A** (HS-ESS1-4); **MS.PS2.B** (HS-ESS1-4); **MS.PS4.B** (HS-ESS1-1),(HS-ESS1-2); **MS.ESS1.A** (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4); **MS.ESS1.B** (HS-ESS1-4); **MS.ESS2.A** (HS-ESS1-1); **MS.ESS2.D** (HS-ESS1-1)
MS.PS2.B (HS-ESS1-6), (HS-ESS2-1); **MS.LS2.B** (HS-ESS2-1); **MS.ESS1.B** (HS-ESS1-6); **MS.ESS1.C** (HS-ESS1-5),(HS-ESS1-6),(HS-ESS2-1); **MS.ESS2.A** (HS-ESS1-5),(HS-ESS1-6),(HS-ESS2-1); **MS.ESS2.B** (HS-ESS1-5),(HS-ESS1-6),(HS-ESS2-1); **MS.ESS2.C** (HS-ESS2-1); **MS.ESS2.D** (HS-ESS2-1)

ELA and Math Standards Connections:

ELA:

RST.11-12.1 Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-ESS1-5),(HS-ESS1-6)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-5),(HS-ESS1-6)
WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence. (HS-ESS1-6)
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-5)
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-1)

SL.11-12.4. Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience**.** (HS-ESS1-3)

MATH:

MP.2 Reason abstractly and quantitatively. (HS-ESS1-5),(HS-ESS1-6),(HS-ESS2-1)
MP.4 Model with mathematics. (HS-ESS2-1)
HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-5),(HS-ESS1-6),(HS-ESS2-1)
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling (HS-ESS1-5),(HS-ESS1-6), (HS-ESS2-1)
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities (HS-ESS1-5),(HS-ESS1-6),(HS-ESS2-1)
HSF-IF.B.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. (HS-ESS1-6)
HSS-ID.B.6 Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. (HS-ESS1-6)
MP.2 Reason abstractly and quantitatively. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4)
MP.4 Model with mathematics. (HS-ESS1-1),(HS-ESS1-4) HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2) ,(HS-ESS1-4)
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1),(HS-ESS1-2), (HS-ESS1-4)
HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HSESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)

Technology & Career Standards:
8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
Career Ready Practices: 1-12

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**
Solar System Terrestrial, Jovian and Exoplanets Satellites Nebula Asteroid, Comets, Meteorites Condensation Nuclei Volcanism Plate tectonics Continental Drift Tides Comparative Planetology Cooper Belt IAU	Ringlets Luna Crater Seismic Waves (P,S,L)	Scale Theory Law Mass Radius Density Force Orbits Orbital Experimental Techniques Phenomena Remote Sensing Probe Magnetic Field Topography Composition Stress Velocity	*Astronomy Today* by Chaisson and McMillan Chapter 6- The Solar System Chapter 7- Earth Chapter 8- The Moon and Mercury Chapter 9- Venus Chapter 10- Mars Chapter 11- Jupiter Chapter 12- Saturn Chapter 13- Uranus and Neptune Chapter 14- Solar System Debris Chapter 15- Exoplanets Online access to internet websites and readings required are below.

THE 5 "E"s	Examples of Learning Activities for the specified "E"	SLO's and Engineering Practices
ENGAGE	**Examples of Engaging Activities:**	
	"What is a Planet? (video discovery education)	4
	Plate Tectonics Simulation Lab	5, 1/; Developing and Using Models
	Plate Tectonics Video (YouTube)	5
	"Origins of Life: How Life Began Documentary Video"	5/ Asking Questions and Defining Problems
EXPLORE	**Examples of Exploring Activities:**	
	Geological Age Lab	6/Obtaining, Evaluating and Communicating Information
	Model of Faults Lab	5/Developing and Using Models
	SeaFloor Spreading Lab	5/Analyzing and Interpreting Data
	Weathering and Erosion Lab	1
EXPLAIN	**Examples of Explaining Activities:**	
	Dating Popcorn Lab - Earth Science Week	1/using Mathematics and Computational Thinking
	Continental Drift Activity Packet Lab -earthref.org.erda	5/Engaging in Argument from Evidence
ELABORATE	**Examples of Elaborating Activities:**	
	Investigating Meteorites Lab	6/Constructing Explanations and Designing Solutions
	Earth History Time Line Investigation	5, 6/Planning and Carrying Out Investigations

EVALUATE	**Examples of Evaluating Activities:**	
	Analyzing Craters of Earth, Moon and Mars To Compare Impact Size and Location / Meteorite Bombardment Activity (Using satellite images)	6/Analyzing and Interpreting Data
	Group Research - Stream Erosion and Deposition	6/Obtaining, Evaluating and Communicating Information

Unit #: 3	**Unit Name: Stars and Stellar Evolution**	**Unit Length:** 35 days

ESSENTIAL QUESTIONS:	Why do we study stars? Why do stars never really die? Why is it important to learn about the structure and function of our sun?	
#	**STUDENT LEARNING OBJECTIVES (SLO)**	**Corresponding DCIs and PEs**
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 that eventually reaches Earth in the form of radiation.** [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]	HS-ESS1-1
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.** [Clarification Statement: Emphasis is on the astronomical evidence of the redshift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (¾ hydrogen and ¼ helium).]	HS-ESS1-2
3	**Communicate scientific ideas about the way stars, over their life cycle, produce elements.** [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]	HS-ESS1-3

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanation and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • 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	**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. (HS-ESS1-1) • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2), (HS-ESS1-3) • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within the 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. (HS-ESS1-2), (HS-ESS1-3) **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 to HS-ESS1-1)	**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. (HS-ESS1-2) • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3) --- **Connection 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. (HS-ESS1-2), (HS-ESS1-4) --- **Connection to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

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. (HS-ESS1-2) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • 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). (HS-ESS1-3)		• 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. (HS-ESS1-2) • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

Connections to other DCIs in this grade-band:
HS.PS1.A (HS-ESS1-2), (HS-ESS1-3); **HS.PS1.C** (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-**3); HS.PS2.B (**HS-ESS1-4**); HS.PS3.A (**HS-ESS1-1),(HS-ESS1-2); **HS.PS3.B** (HS-ESS1-2); **HS.PS4.A** (HS-ESS1-2)

Articulation of DCIs across grade-bands:
MS.PS1.A (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3); **MS.PS2.A** (HS-ESS1-4); **MS.PS2.B** (HS-ESS1-4); **MS.PS4.B** (HS-ESS1-1),(HS-ESS1-2); **MS.ESS1.A** (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4); **MS.ESS1.B** (HS-ESS1-4); **MS.ESS2.A** (HS-ESS1-1); **MS.ESS2.D** (HS-ESS1-1)

ELA and Math Standards Connections:

ELA:

RST.11-12.1 Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-ESS1-1),(HS-ESS1-2)
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2), (HSESS1-3)
SL.9-10.4. Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. (HS-ESS1-3)

MATH:

MP.2 Reason abstractly and quantitatively. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4)
MP.4 Model with mathematics. (HS-ESS1-1),(HS-ESS1-4) HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2) ,(HS-ESS1-4)
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1),(HS-ESS1-2), (HS-ESS1-4)
HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HSESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)

Technology & Career Standards:
8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
Career Ready Practices: 1-12

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**
Polaris Alfa Centauri HR Diagram Sunspots Solar Flare Prototype Brightness Corona Nuclear Fission/Fusion Umbra Penumbra Binary Stars Dwarf Black hole Giant Super Giant Prominences Apparent Magnitude	Variability Apogee Perigee Perihelion Polarity Classification Direct vs Indirect Measurements Main Sequence Absorption Expectancy Lifetime Novas Relativity	*Astronomy Today* by Chaisson and McMillan Chapter 16- The Sun Chapter 17- The Stars Chapter 18- Interstellar Medium Chapter 19- Star Formation Chapter 20- Stellar Evolution Chapter 21- Stellar Explosions Chapter 22- Neutron Stars and Black Holes Online access to internet websites and readings required are below.

THE 5 "E"s	Examples of Learning Activities for the specified "E"	SLO's and Engineering Practices
ENGAGE	**Examples of Engaging Activities:**	
	"What is a star?" (video from Discovery Education)	3/ Asking Questions and Defining Problems
	The Solar Cycle - article reading	1
	Neil Degrasse Tyson: "Blackholes and Other Cosmic Quandaries" (video)	2/ Analyzing and Interpreting Data
EXPLORE	**Examples of Exploring Activities:**	
	Graphing Sunspots #2	1/Using Mathematics and Computational Thinking
	"How Big Is That Star?"	2, 3/ Constructing Explanations and Designing Solutions
EXPLAIN	**Examples of Explaining Activities:**	
	Solar Cycle Prediction - Article by Kristof Petrovay (NASA)	1/Engaging in Argument from Evidence
	HR Diagram Lab	1/Analyzing and Interpreting Data
ELABORATE	**Examples of Elaborating Activities:**	
	Stellar Evolution Scavenger Hunt (web based)	1/Obtaining, Evaluating and Communicating Information
	Star Spectra	2, 3/Planning and Carrying Out Investigations
	Sunspots (using a telescope for tracking)	1/Obtaining, Evaluating and Communicating Information

EVALUATE	**Examples of Evaluating Activities:**	
	NOVA Sun Lab Lesson (student research project)	1, 2, 3/Obtaining, Evaluating and Communicating Information
	Eat My Dust - Molecular cores to stars	2/Using Mathematics and Computational Thinking

Unit #: 4	**Unit Name: Galaxies and Cosmology**	**Unit Length:** 35 days

ESSENTIAL QUESTIONS:	What are we capable of learning about our universe? How the Redshift and Blueshift determines the fate of galaxies? What will be the ultimate fate of our universe?	
#	**STUDENT LEARNING OBJECTIVES (SLO)**	**Corresponding DCIs and PEs**
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 that eventually reaches Earth in the form of radiation.** [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]	HS-ESS1-1
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.** [Clarification Statement: Emphasis is on the astronomical evidence of the redshift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (¾ hydrogen and ¼ helium).]	HS-ESS1-2
3	**Communicate scientific ideas about the way stars, over their life cycle, produce elements.** [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]	HS-ESS1-3

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanation and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • 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	**ESS1.A: The Universe and Its 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**.** (HS-ESS1-2) • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within the 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. (HS-ESS1-2), (HS-ESS1-3) **ESS2.A: Earth Materials and Systems** • 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,	**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. (HS-ESS1-2) • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3) --- **Connection 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. (HS-ESS1-2), (HS-ESS1-4) --- **Connection to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

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. (HS-ESS1-2) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • 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). (HS-ESS1-3) --- **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	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. (HS-ESS2-4) **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. (HS-ESS2-4), (secondary to HS-ESS2-2) • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4) **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. (HS-ESS3-5)	• 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. (HS-ESS1-2) • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

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. (HS-ESS1-2)		

Connections to other DCIs in this grade-band: HS.PS1.A (HS-ESS1-2), (HS-ESS1-3); **HS.PS1.C** (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-**3); HS.PS2.B (**HS-ESS1-4**); HS.PS3.A (**HS-ESS1-1),(HS-ESS1-2); **HS.PS3.B** (HS-ESS1-2); **HS.PS4.A** (HS-ESS1-2)
Articulation of DCIs across grade-bands: MS.PS1.A (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3); **MS.PS2.A** (HS-ESS1-4); **MS.PS2.B** (HS-ESS1-4); **MS.PS4.B** (HS-ESS1-1),(HS-ESS1-2); **MS.ESS1.A** (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4); **MS.ESS1.B** (HS-ESS1-4); **MS.ESS2.A** (HS-ESS1-1); **MS.ESS2.D** (HS-ESS1-1)
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MP.4 Model with mathematics. (HS-ESS1-1),(HS-ESS1-4) HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
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HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1),(HS-ESS1-2), (HS-ESS1-4)
HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HSESS1-1),(HS-ESS1-2),(HS-ESS1-4)
HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4)

Technology & Career Standards:
8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
Career Ready Practices: 1-12

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**
Galaxy- Milky Way Andromeda Galactic Bulge, Center and Disk Spiral, Elliptical, Irregular Galaxy Red Shift Blue Shift Dark Matter Drake Equation Cosmic Background Radiation Red Dwarf Pulsars Radio Lobes	Interpretation Spatial Distribution Distance Measurement Technique Large Scale Distribution Epoch	*Astronomy Today* by Chaisson and McMillan Chapter 23- The Milky Way Galaxy Chapter 24- Galaxies Chapter 25- Galaxies and Dark Matter Chapter 26- Cosmology Chapter 27- The Early Universe

Quasar		Chapter 28- Life in the Universe Online access to internet websites and readings required are below.

THE 5 "E"s	Examples of Learning Activities for the specified "E"	SLO's and Engineering Practices
ENGAGE	**Examples of Engaging Activities:**	
	Space Science Documentary -" End of the Earth "- Science Channel Series Videos / Cosmos: A Spacetime Odyssey (video)	2
	"Life and Death of a Star "- Science Channel Series (video)	3/ Asking Questions and Defining Problems
	Vastness of Space Activity # 1" (includes NOVA video and analysis questions)	2/Engagement in Argument from Evidence
EXPLORE	**Examples of Exploring Activities:**	
	Dark Matter Possibilities Lab	2/Planning and Carrying Out Investigations
	Build Your Own Galaxy Lab	2
	Modeling the Universe	2 / Developing and Using Models

	Moving Stars and Planets Activity # 2	3
EXPLAIN	**Examples of Explaining Activities:**	
	Galaxy Classification and Evolution Lab	2/Analyzing and Interpreting Data
	"How Old is the Universe " Lab	1/Using Mathematical and Computational Thinking
	Hunting for Planets Activity # 3	2
ELABORATE	**Examples of Elaborating Activities:**	
	Dark Matter : "Probing What You Cannot See?"	2/Constructing Explanations and Designing Solutions
	Determine redshift in a Receding Star	2/Analyzing and Interpreting Data
	Habitable Conditions Activity # 4	1,2
EVALUATE	**Examples of Evaluating Activities:**	
	Parallax Lab - How Far Is It Activity	1, 2/Using Mathematics and Computational Thinking
	Looking for Signs of Life Activity # 5	3
	Cosmic Survey - What Are Your Ideas About Ideas About The Universe?	1,2,3 / Obtaining, Evaluating and Communicating Information