Astronomy through the Ages
Learning Text Features and Research Through Astronomy

Wendy S. Girnis

Introduction

I will be writing a blended curriculum unit that focuses on using scientific text to understand nonfiction text features. Students will also research how astronomers throughout history have come to learn about the universe and how the tools of the time helped to form that understanding. I currently teach third grade. Third grade students enjoy reading about the solar system and astronomy in general. They have looked at the night skies, watched the phases of the moon, and have learned about day and night in the lower grades. Using technology in this unit will help my students to become more proficient as 21^{st} century learners and help them understand the universe they live in.

Background

The students in my school come from many different backgrounds. There are approximately 600 K-5 students in my school. Our school services students from a low socioeconomic status and is 100% free breakfast and lunch. As a third-grade teacher, I have approximately 23 students in my class, approximately half are ELL students. Third graders are ages 8 and 9.

My students are very computer literate. My classroom is 1-to-1 with Chrome Books. The students are familiar with Schoology, our LMS (Learning Management System), Google Drive, and various on-line research sites such as Common Lit, and Newsela which contains digital content. My students work well collaboratively with each other most of the time. My goal for this lesson is to have my students improve upon their knowledge of understanding text features using scientific texts. This lesson will also fit into the broader context of learning, which is to facilitate my students' learning to move them towards becoming 21st century learners and problem solvers. Today's students need to be critical thinkers, problem solvers, communicators, and collaborators. My classroom is moving from a teacher centered classroom to a student centered one. This shift in pedagogy has me prioritizing student interaction, communication, and collaboration in my classroom. Blended lessons do this by combining face-to-face discussions, as well as delivery of digital content to give my students a chance to practice 21st century skills required for future success.

Rationale

In my twenty-three years of teaching, I have noticed that students spend more time on their digital devices than they do with a book. With the implementation of Common Core State Standards, there is more focus on delving deeper into text, fiction, as well as nonfiction. Questions are more rigorous and students are required to think more deeply to answer them. With that said, reading deeply is difficult for third graders. The expectations for reading in third grade are a lot more rigorous than second grade's expectations. In third grade, students move from Learning to Read, to Reading to Learn. This is a difficult transition for some students. By third grade we are asking students more rigorous, open ended questions that require an answer of more than a few words. I have noticed that most third-grade students will read and write more when given a chance to use computers, so this will be a blended lesson with the final product completed in Google Drive. To increase students' understanding of the universe they live in, it will also include the use of our district planetarium to experience the history of astronomy through the eyes of astronomers like Ptolemy, Galileo, Annie Jump Cannon, Subrahmanyan Chandrasekhar, and Neil DeGrasse Tyson.

This year, my focus will be on creating more perceptive readers. Third graders need to be interested in the subject matter to delve deeply into it. We know that throughout history, the stars and planets have been looked upon for predicting the future and planting crops. The main unit will cover how search tools, including nonfiction text features help readers better understand and answer questions. They will accomplish this by using print and electronic text features to locate and understand information. Students will also discover and explain how ideas in scientific texts connect. They will compare two texts on the same topic and will use research to explain about the information they discovered. Students will then clarify their understanding of a presentation by asking questions and presenting their research.

Students will be introduced to nonfiction text features. These features will be illustrations, captions, sidebars, bold print, glossary, index, electronic menus, icons, key words, hyperlinks. Students will use nonfiction text about astronomy to understand these features. Using astronomy, which is a high interest subject with third graders will help to reinforce the lessons taught. Once students understand the nonfiction text features and how they assist in finding specific information, students will then begin a research project about a specific astronomer.

Learning Objectives

The Learning Objectives of this unit is to have my students explore scientific text by learning about text features, comparing texts, and completing a research paper using scientific texts. Students will learn about titles, headings, side bars, glossaries, bold words, illustrations, captions, graphs and maps, and how they help understanding of nonfiction text. Their research paper will have them using various texts to research an astronomer and their contributions to their profession.

Concepts

Man has looked upon the stars since the beginning of time. Early man was awed and frightened by the sky. Cave art found in France and Germany, have been found to contain the oldest Lunar Calendars and Earliest Constellations. "The astronomer-priests of these late Upper Paleolithic Cultures understood mathematical sets, and the interplay between the moon's annual cycle, ecliptic, solstice, and seasonal changes on earth. "[1] Markings depicting the lunar cycle were found caved into animal bones and cave walls. Although the carvings weren't exact, it does show that that mathematical skills were used in understanding the phases of the moon and the tracking of the seasons.

Ancient English Astronomy

As early as 3,000 BC, the first stones of Stonehenge in Wiltshire, England were being placed. “There is scarcely any doubt that astronomy did take place at Stonehenge, it’s just difficult to tell exactly what went on there. ”[2] Early astronomical observations at Stonehenge were probably simplistic. The placement of the stones aligns with the sun and moon, although they don’t line up exactly and are off center. This lack of accuracy is one of the reasons that scientists believe that Stonehenge was used for simple astronomical observations.

Babylonian Astronomy

“The earliest written records were astronomical observations by the Babylonians who recorded the position of planets, times of eclipses and more. ”[3] The earliest recorded observations were found on the Nebra sky disk. This disk dates to 1,600 BC. “This 30 cm bronze disk depicts the Sun, a lunar crescent and stars (including the Pleiades star cluster). ”[4] The Babylonians charted planetary motions, and the seasonal changes. They also used the stars to plan plantings and harvesting, as well as for worship. “The Harappans, Mayans, and ancient Chinese used astronomy to keep track of time, orient their cities, and try to predict the future. "[5]

Indian Astronomy

Indian astronomers observed the stars and planets, created charts, and used them for astrology and predicting the future dating back to 2000 BC. Indian astronomers also developed mathematical models and theories.

The Rigveda, one of the foremost texts of Hinduism, “shows that the Indians divided the year into 360 days, and the year was subdivided into 12 months of 30 days. ”[6] The calendar was altered every five years by adding 4 days to it. They also built their alters to align with the cardinal points.

The Indians shared ideas with the Babylonians, and Greeks. “This exchange of theories and philosophy was extremely important to the development of astronomy. ”[7] During the Siddhantic Era, the solar year was charted. This included seasonal equinoxes, as well as eclipses. Eventually Indian astronomers were suggesting that the sun was a star. They also comprehended that the earth was a sphere and attempted to calculate its circumference.

Mayan Astronomy

The Mayans had many astronomical accomplishments. Like Ptolemy, the Greek astronomer, the Mayan astronomers, without the use of modern equipment, collected accurate measurements of the Lunar month, synodic periods of Mars and Venus, and the solar year. Their measurements were almost as accurate as Ptolemy. Both the Mayans and Ptolemy had access to centuries of observational records gathered by other cultures.

The Mayans did not try to understand the motion of the sun, stars, and planets “Instead, the heavens were treated as an immense, accurate piece of clockwork that was used in the same sense as the signs of astrology, to predict the future. ”[8] “They used observatories, shadow-casting devices, and observations of the horizon to trace the complex motions of the sun and stars, in order to observe, calculate and record this information in their chronicles, or codices. ”[9]

Like the Egyptians, the Mayans built buildings to align with the spring and fall equinox. The sun would “cast its rays through small openings in a Maya observatory, lighting up the observatory’s interior walls. ”[10] The Mayans believed that the sun and moon moved across the sky with the help of the gods. At night, they thought that the sun and moon passed through the underworld and that evil gods were trying to stop them. Sacrifices were made so that those who were sacrificed could help the sun and moon escape from the evil gods.

Greek Astronomy

The Greeks became known for their contributions to astronomy. Actually, “their knowledge was built upon the solid foundations laid by other great cultures. ”[11] This knowledge was gained when Alexander the Great conquered Persia in 331 BC. The Greeks also obtained a lot of knowledge from other cultures due to the trade routes passing through Greece.

Greek philosophers like Thales and Pythagoras wanted to understand the cycles of nature, such as the stars and seasons. They wanted to know the how and why things worked the way they did. In 585 BC, Thales, who was known as one of the Seven Sages of Greece, was the first person to predict a solar eclipse. Thales’ prediction of the solar eclipse was probably a result of his knowledge of the Babylonian astronomy. Thales also went to Egypt to learn geometry and is also credited with inventing trigonometry. This shows that he understood that there was a link between astronomy and math.

Pythagoras, who we associate with mathematics, was one of the first Greeks to be called a philosopher. “Astronomy and harmony were, he said, sisters. ”[12] Pythagoras proposed that the Earth must be round and floats freely in space. He reasoned “that if the moon and other celestial bodies were spherical, then it made sense that the earth would be too. ”[13]

Aristarchus, who was Archimedes teacher, along with Eratosthenes, who worked in the Library of Alexandria, was the first to suggest that it was the earth which rotated on its axis and the sun and stars were stationary. This would eventually motivate Copernicus to come up with his own theory. Separately, Eratosthenes measured the circumference of the earth around 240 BC. His measurements were fairly accurate. Aristarchus estimated the distances between the sun and the earth, and the moon and the earth that were reasonable. He believed that the earth was at the center of a universe that was expansive and not small as was thought at the time.

In 100 BC, another Greek, Hipparchus, made the most important contribution to astronomy. Hipparchus used observation and data to come up with scientific theories. He “calculated the length of the year to within 6. 5 minutes and discovered the precession of the equinoxes. ”[14] “The precession of the equinoxes refers to the observable phenomena of the rotation of the heavens, a cycle which spans a period of (approximately) 25,920 years, over which time the constellations appear to slowly rotate around the earth, taking turns at rising behind the rising sun on the vernal equinox. "[15] Hipparchus also developed the first star catalog and recorded the constellations. This catalog listed over 800 of the brightest stars in the night sky.

The Greeks "made accurate measurements and moved the idea of the structure of the universe away from gods and superstition. "[16] They used math to construct models of the universe and tried to explain the motions of the universe and what causes them. Unfortunately, Ptolemy and his Geocentric model of the universe was the accepted model until the heliocentric theory developed by Copernicus in 1543,

Egyptian Astronomy

The Egyptians studied the heavens for agricultural necessities and out of superstition. Astronomy developed in Egypt because of the yearly flooding of the Nile River. As far back as 5th Millennium BC they had created a calendar and an independent set of constellations. These constellations were different from those of the Greeks.

The Egyptians used sundials to tell time. Egyptian astronomers divided the day into 24 hours. The night sky was divided into 36 groups to tell time at night. These groups were called Decans. They were also aware that the year was 365 days long. The Egyptians had 12 months with each month having 30 days.

Many of the Egyptian buildings were either aligned with the rising of the midwinter sun for agricultural purposes, or with the cardinal points. "The Great Pyramid of Giza has southern facing airshafts that point to the star Sirius, with its significance in marking the start of the Egyptian year, and to Orion, associated with death and rebirth. "[17]

Native Americans

For Native Americans, "Astronomy served as the basis for governance, agriculture practices, and more. And studying the stars also caused tribes to theorize about the beginning of life in the universe. "[18] Many native cultures also tied mythology to the movements of the stars and to phenomena, such as eclipses.

Modern Day Astronomy

Modern day astronomy started with the invention of the telescope in 1609. Using the telescope provided astronomers a magnified view of the heavens. It allowed man to view the heavens more clearly. Before the telescope, objects were named for the way they looked to the naked eye; the Milky Way, Andromeda Nebula, and Magellanic Cloud. These names lacked reference to any existence of stars.

Observatories

Observatories were built to observe celestial objects. They were monolithic structures used for timekeeping and creating a calendar by observing the motion of the sun and moon, as well as other celestial bodies. Stonehenge was a monolithic structure built between 3000 and 1520 BC. Around the same time in Babylonia, observations of the sun, moon and planets were being made from a step pyramid called a Ziggurat. While the Babylonians were making their observations, the Mayans were making theirs. These observations were made without any instruments for accurate measurements.

Hipparchus, known for calculating the length of a year, developing the first star catalog and recording the constellations, built an observatory on the island of Rhodes around 150 BCE. This was one of the first observatories to "utilize instruments for accurately measuring the positions of celestial objects. "[19]

There were many observatories built in the Islamic World between 800 – 1600. These were the predecessors of modern observatories. Many of these observatories were built near Cairo Egypt. Around 1005, an observatory was built on Mount Muqattam, located outside of Cairo. During this time, astronomer Ibn Yanus who the observatory was built for wrote the Hakimi Tables which contains calendar tables for the Muslim, Persian, and Syrian calendars, as well as trigonometric functions and finding the longitude of the moon. After his death, the observatory was no longer used.

"The first notable premodern European observatory was built by King Frederick of Denmark for Tycho Brahe in 1576. "[20] It was the last observatory built before the invention of the telescope. The instruments used at the observatory included "quadrants, parallactic rulers, and armillary spheres. "[21] Supported by the state, the observatory cataloged more than 1000 stars.

Telescopes

"Telescopes are essentially giant eyes that can collect far more light than our own eyes. "[22] The invention of the refracting telescope in 1609 by Galileo allowed him a view of the heavens not seen before. Galileo's telescope had two lenses that were used to magnify objects. With his telescope of a magnification of 9x, he was able to see the four largest moons of Jupiter and the topographical features of the moon. He was also able to see the individual stars in the Milky Way and the phases of the planet Venus.

Shortly after, in 1616, a concave mirror was added to the telescope by Niccolo Zucchi, and in 1630 Christoph Scheiner added a convex mirror. The reflecting telescope was invented. The mirror helped to correct the bending of light through the glass lenses. The mirror doesn't bend the light because light doesn't go through a mirror it reflects it. Throughout the 1600s, improvements to the mirrors were made to correct chromatic aberration which "is a common optical problem that occurs when a lens is either unable to bring all wavelengths of color to the same focal plane, and/or when wavelengths of color are focused at different positions in the focal plane. "[23]

Reflecting telescopes make up almost all of the telescopes used today. The reasons reflecting telescopes are used is because instead of having both sides of a lenses shaped to a precise shape, "the reflecting surface of a mirror must be precisely shaped, and the quality of the underlying glass is not a factor. "[24] Secondly, mirrors are mounted at the bottom of the telescope.

Stablization of the telescope isn't a factor due to the weight of the mirror at the bottom. Because mirrors can be made larger, than glass lenses, larger reflecting telescopes are being built. For now, the largest optical telescope on earth is the Gran Telescopio Canarias located in the Canary Islands. The diameter of this telescope is 10. 4 meters.

There are other types of telescopes being used today. One type is the imaging telescope. An imaging telescope is actually just a camera. It allows you to take photographs of stars, nebula and galaxies. Filters can be combined to filter out visible light and permit other wavelengths to filter through. Unfortunately, the earth's atmosphere, weather, and daylight interfer with ground based observatory telescopes. Waiting for a cloudless day and doing observations in the evening alleviate problems with weather and daytime. Unfortunately, you can't do anything about the atmosphere while on earth. The atmosphere causes the light from the images to bend because it has to pass through the various pockets of hot and cold air in the atmosphere.

To alleviate atmospheric bending of light, the Hubble telescope was sent into space in 1990. Sending telescopes into space allows the telescope to obtain clearer pictures without atmospheric interference, but they also are able to pick up nonvisible light. On earth, a telescope can only pick up visible light and radio waves. There are many other wavelengths that can be picked up by telescopes in space. "The Hubble telescope is the most famous observatory in space – and it is used to observe infrared and ultraviolet light in addition to visible light. "[25]

Other telescopes being used to gather information are radio telescopes, infrared telescopes, ultraviolet telescopes, and x-ray telescopes. Radio telescopes look for radio waves emanating from the sun or other stars. Infrared telescopes "detect and resolve infrared radiation from sources outside Earth's atmosphere such as nebulae, young stars, and gas and dust in other galaxies. "[26] Ultraviolet light is absorbed by the atmosphere, so ultraviolet telescopes in space are able to observe those wavelengths of about 400 nanometers in the ultraviolet part of the spectrum which is used to detect celestial bodies. Finally, the x-ray telescope was created to detect x-rays which have a small wavelength. X-ray telescopes "help scientists to understand the distribution of hot gas between galaxies, the physics of supernova remnant expansion, among other things. "[27]

Astronomers

We imagine astronomers spending their nights looking up at the heavens and observing the celestial bodies. Not only do astronomers make their observations, but they keep data, not for a week or two, but sometimes for years or even decades. Using the data they collect, and applying physics to interpret the data, they begin to gain an understanding of the universe we live in. Throughout time, there have been many astronomers who have made an impact on our way of thinking about space and our place in the universe by their observations and the data they kept.

Claudius Ptolemy

Ptolemy was a geographer and astronomer. It is noted that he was born in Egypt probably to Greek parents between 85 and 100 AD and died between 165 – 170 AD in Alexandria. His name is a combination of Egyptian and Roman names. He began to make observations of the heavens from Alexandria. It is believed that Ptolemy utilized the library in Alexandria for its valuable reference materials. His greatest work was the Almagest which was a star catalogue as well as an astronomy text which is divided into 13 books. Using data from hundreds of years, dating back to the Babylonians, he was able to analyze it to create data tables detailing the motions of celestial objects. “The *Almagest* included a catalogue of over a thousand stars, recording their positions, constellations, and relative brightness’s; and a mathematical model predicting the movements of the planets. ”[28] Using his data, he created a geocentric model that showed Mercury, Venus, Mars, Jupiter, and Saturn, along with the sun, in concentric circles around Earth. This model replicated the motion of these celestial objects. The planets weren’t in the correct order as he showed Mercury closest to the Earth. This model was the accepted model of the universe for 1,500 years.

Galileo Galilei

Galileo was known as an astronomer, mathematician, physicist, and The Father of Modern Science. He was born in 1564 in Pisa, Italy and died on January 8, 1642. Based on information about an invention of a spyglass in the Netherlands, in 1609, Galileo created the first refracting telescope. This invention changed the course of science and it also changed man’s view of space.

Using his telescope, Galileo was able to explore objects in the day and night sky and saw details never seen. Through his telescope, Galileo viewed the phases of the moon and observed that the surface of the moon wasn’t smooth but was uneven with mountains and craters. Galileo also turned his telescope to Venus. He noticed that Venus went through the same phases as the moon did. He discovered that the sun’s surface wasn’t perfect. When Galileo viewed Saturn, he was able to see the rings around the planet. In Galileo’s time, the Milky Way to the naked eye looked like a white streak across the sky. With the Telescope, Galileo was able to see individual stars and the empty space between them.

In 1610, he discovered the four largest moons of Jupiter, Io, Europa, Ganymede, and Callisto. Today, these four moons are known as the Galilean moons. Because of his discoveries, specifically the phases of Venus, Galileo began to believe in a Heliocentric / Sun Centered Universe. “This discovery provided evidence in support of the Copernican system and showed that everything did not revolve around the Earth. ”[29]

Galileo published writings about his many astronomical discoveries. In 1616, the Catholic Church put Galileo on trial for his belief in a Heliocentric Universe. The church forced him to retract his beliefs or be charged with Heresy. Galileo continued his work in astronomy with the blessing of his friend Cardinal Maffeo Barberini who would become Pope Urban VIII. Still Galileo was not allowed to express his beliefs of a Heliocentric Universe.

In 1632, that changed. Galileo published Dialogue Concerning the Two Chief World Systems. In this publication, Galileo confirmed his belief and supported the Copernican theory. Because of this, he was convicted of Heresy and put under house arrest for the remainder of his life.

Annie Jump Cannon

Annie Jump Cannon was born in Dover, Delaware, December 11, 1863. She gained fame working with Edward Pickering in the Harvard College Observatory. Pickering wanted to catalog stars using photographs that were taken using cameras and telescopes outfitted with prisms. The prisms break light into their spectral colors. “It can give scientists information on stars, planets, and galaxies especially their chemical composition and whether they are in motion through space. ”[30]

Annie loved to look at the night sky as a child and studied the constellations from her homemade rooftop observatory. She attended the all-girls school, Wellesley College, which offered the same courses as the male universities did. While there, she excelled in her physics classes. These classes taught her about the science of energy and matter. Annie graduated with a degree in physics in 1884.

Annie returned to take astronomy classes at Wellesley and Radcliffe, in 1894. Being a student at Radcliffe, allowed her to use the telescope located in the Harvard Observatory. “In 1896, she became a member of the group that historians of science have dubbed "Pickering's Women," women hired by Harvard College Observatory director Edward Pickering to reduce data and carry out astronomical calculations. ”[31]

Eventually, Annie was charged with taking photographs of the sky each night, which originally was men’s work, and studying them for their position and spectra. The spectrograms, which are photographic plates, were examined by the women working in the observatory known as “computers. ” “Their job was to analyze the type of light coming from each star by looking for telltale dark lines. ”[32] The spectral lines tell astronomers what elements a star contains as well as its temperature based on the wavelength of the spectral lines.

The system used to classify stars didn’t make sense to Annie. Between 1911 and 1915, she came up with a simpler system to classify them. The system ranked the stars from the hottest to coolest. Annie developed a mnemonic to remember it; Oh Be A Fine Girl Kiss Me. The system she devised is still being used today. During this time, she cataloged approximately 250,000 stars. Her main contribution to astronomy was stellar spectral classification, which is based on the luminosity and temperature of a star. Depending on the temperature of the star, certain absorption lines can be observed. The absorption lines are caused by a certain frequency of light that is absorbed by a gas. The absorption lines on a stellar spectrum can tell us if a star is made of hydrogen gas or another element.

During her career at Harvard, Annie classified nearly 400,000 stars. She was honored with a Doctor of Science degree from Oxford University, and the Draper Medal of the National Academy of Sciences. At seventy-five, Annie was made a full professor of astronomy at Harvard. Annie died in Cambridge, Massachusetts on April 13, 1941

Subrahmanyan Chandrasekhar

Subrahmanyan Chandrasekhar was a twentieth century astrophysicist. He was born in 1910 in Lahore, British India. He was homeschooled until he was 12 years old. Chandrasekhar graduated

Hindu High School at 15 years old and went to Presidency College and then onto Cambridge University in England.

Chandrasekhar began to do research in astrophysics. He became interested in what happens to stars as they age. In 1930, at the age of nineteen he created the Chandrasekhar Limit. This is the limiting mass "above which no stable white dwarf star can exist. "[33] The limit is 1. 4 solar masses. "A star that ends its nuclear-burning lifetime with a mass greater than the Chandrasekhar limit must become either a neutron star or a black hole. "[34] Chandrasekhar's theory was challenged by Stanley Eddington. Other researchers didn't accept his theory because Eddington's status in the scientific community had more weight. Due to this, discoveries of black holes and neutron stars were put on hold for at least two decades.

In 1930, Chandrasekhar earned his Ph. D. degree from Cambridge University. It was right after this that he was inspired and formed the Chandrasekhar Limit. During the 1930s, he lectured at Harvard University, and then was offered a position at the Yerkes Observatory, University of Chicago. By the time 1938 rolled around, he became assistant professor of astrophysics. Chandrasekhar became a full professor at the University of Chicago in 1942. He continued to work in astrophysics, becoming a Morton D. Hull Distinguished Service Professor of Astrophysics. He also became the managing editor of the Astrophysical Journal. Chandrasekhar stayed at the University of Chicago for his whole career. In 1980 he retired from the University, although he continued to work on research and published his work on the mathematical theory of black holes in 1983. He was finally rewarded for his work in 1983 when he was awarded the Nobel Prize on his work on stars and their evolution.

In 1999, the Chandra X-ray telescope was launched into space. The telescope operated by Harvard-Smithsonian Center for Astrophysics was named after Subrahmanyan Chandrasekhar.

Neil deGrasse Tyson

Neil deGrasse Tyson is a popular present-day astrophysicist. He is the director of Hayden Planetarium in New York City, and is also a writer and TV and Radio personality. He was born October 5, 1958 in New York City.

As a child, Neil would go up to the roof of his house to observe the stars. At 11 years old he took astronomy and astrophysics classes at the Hayden Planetarium. He attended the Bronx High School of science and graduated from there in 1976. He attended Harvard University and received a bachelor's degree in Physics. He then attended Columbia University to get his doctorate in astrophysics. He worked at Princeton University doing research in astrophysics before he was hired at Hayden Planetarium in 1994. In 1996 he became the director of the planetarium. People constantly ask him if there is a difference between being an astrophysicist or an astronomer. The difference is that an astrophysicist uses physics to learn about the universe.

Neil deGrasse Tyson loves to educate the public about science, specifically about space. He is interested in supernovas. "He was also known for using ultraviolet (UV) photometry--the measurement of the intensity of UV light emitted by a celestial body--to study various phenomenon. Tyson says that ninety-nine percent of what we know about our universe is learned through analyzing light. Much of Tyson's research work focused on improving scientists' understanding of how stars and galaxies are formed. "[35]

Neil deGrasse Tyson has written many books about space. The books he writes are geared towards the public and have to do with astrophysics. He has appeared on numerous television and radio shows. "Throughout his career, Tyson was committed to using his position as a means of educating others, whether through social media, books, television, or other venues. "[36]

Strategies

The strategies that I will be using will be a graphic organizer, cooperative learning and effective questioning.

The graphic organizer will be used to compare the information in the scientific texts the students will be using. Another graphic organizer will be used to collect information on the astronomer that they will be researching.

Cooperative learning will also be used, since students will be paired up to work on the text features of scientific texts, as well as comparing information during their research. An example of a pairing strategy is as follows. Pair students either by same reading ability or by high level readers with low level readers. Use the following steps to pair high-level readers with low-level readers. First, list the students in order from highest to lowest according to reading ability. Next, divide the list in half. Then place the top student in the first list with the top student in the second list. Continue until all students have been partnered. Remember to be sensitive to pairings of students with special needs, including learning or emotional needs. You can adjust pairings as necessary.

I will also use effective questioning. Higher order thinking questions help students with critical thinking skills. Students need these skills as they prepare for the future. I will focus on reasoning and analyzing.

Classroom Activities

My unit will include three lessons. The lessons will range from 1-5 days, with the unit taking a total of 6 weeks to complete. The lesson will be delivered using the blended learning model. The blended learning model requires the teacher to deliver the introductory content to the students. Once the content is delivered, the online component can be completed in the classroom or in another location such as home. As students as working on their online lessons, they will be checking in with the teacher to update their progress, ask questions, or ask for help. Once the online component is completed, students will be responsible to complete a product to showcase their learning.

Students will be working in groups of four and paired for this unit. An example of a pairing strategy is as follows. Pair students either by same reading ability or by high level readers with low level readers. Use the following steps to pair high-level readers with low-level readers. First, list the students in order from highest to lowest according to reading ability. Next, divide the list in half. Then place the top student in the first list with the top student in the second list. Continue until all students have been partnered. Remember to be sensitive to pairings of students with special needs, including learning or emotional needs. You can adjust pairings as necessary.

Activity 1: - Introduce Text Features

Day 1

On the first day of the lesson, students will be introduced to text features of hard copy nonfiction text. Students will be seated in groups of four. They will be given sticky notes and asked to write down all the non-fiction text features they are familiar with. Students will be told that they have two minutes to write down the text features. They will write down one text feature per sticky note. As they write down a text feature, they will put the sticky note in the middle of their group. After two minutes, students will be directed to group like text features. Give students about a minute to do this. Have students share out the text features they have generated.

Once you have a list of the text features generated by the students, you will be using LearnZillion: “Add Text Features to Informational Writing. ” After viewing and discussing the LearnZillion lesson, students will be given an exit ticket. The exit ticket will ask them to name 3 text features they learned about and how those text features are used to help them comprehend nonfiction text. Produce a vocabulary list on chart paper of the features and include pictures to help those students who need extra support.

Day 2

For an activating strategy for Day 2, have students work with a partner to name and explain the text features they learned the day before. Call on a few students to share out. Explain that today they will be learning about Digital Text Features. These are features that help us navigate and obtain information from web pages. Students may not be as familiar with these features as they were with the hard copy ones. Give students one minute to work with their partner to come up with a list of digital text features. After one minute, have students share out, and make a list of features they shared with you.

Students will then be introduced to digital text features through a Nearpod lesson called, “Electronic Text Features. ” Nearpod is an interactive digital classroom tool. The Nearpod lesson will cover text features such as, hyperlinks, sidebars, interactive maps, keywords and such. Students will engage with the Nearpod lesson. Once the lesson is complete, the students will complete an exit ticket that is built into the Nearpod. The exit ticket is a Fill in the Blank format and a quick open-ended question, “Why do we use electronic text features?”

Day 3

To activate today’s lesson students will get a Venn Diagram and text feature cut outs. Students will work with a partner to sort the digital and hardcopy text features. When students have completed the task, review the Venn diagram answers with the class and have students justify why the text feature was put where it was.

Once the Venn diagram activity is completed, students will use several children's books, magazines, and websites that are based on astronomy to do a text feature scavenger hunt. Students will look for specific text features and write down how those text features help them to comprehend the text. When students have completed the activity, we will review each feature and how it enhances the understanding of informational text.

Activity Two – Comparing Scientific Texts

Day 1- 2

Before students begin, review the importance of text features with the students. In order to do this, give students a page of text that does not have a text feature associated with it and have them read the text independently and then talk to their partner about what the text means. After about 30 seconds, give students the same text, but with the text feature included. Have them discuss with their partner, how the text feature has helped them understand the text and the information the author wanted them to know. Have students share out.

Students will work in pairs to compare two scientific texts. Model how to compare scientific texts and how to fill in the "Comparing Scientific Texts" graphic organizer. The graphic organizer is a Venn diagram. One side is for Article 1 information, the other side is Article 2 information, and the middle is what is common to both articles. To model this, prepare two different pieces of text with similar text features and topic. For example, both articles can be about the moon, the text feature might be a labeled picture of the moon, but some of the information contained in the texts should be different. Have students work with their partner to discuss the information the texts are giving them. Have students share what they discussed. As a class, you will fill in the Comparing Scientific Text graphic organizer.

Students will compare similar text features found in each text and the information those features support using two hard copy texts, two digital texts, or a combination of both. Students will be able to choose the texts they want to use. Students will be given an astronomy topic and the Comparing Scientific Texts graphic organizer. Topics that the students will be given can be one of the planets or moons in the solar system, the sun, asteroids, galaxies, or any other astronomy topic. The graphic organizer that the students will get will have them write down the titles of the two nonfiction texts, write down the text features they will compare or contrast, such as a picture, chart, or map, and how the text feature they chose support the informational text to make it more comprehensible. If there is time, students can choose a second one.

Once students have finished working in pairs, they will meet with another pair and discuss the text features they chose and how it helped them understand the text. Once students are done, we will reconvene as a class and discuss the various types of text features and how those text features helped us comprehend the text. Students will complete an exit ticket. They will get a paper with two examples. One with just text, and one with lots of text features. The question they need to answer is "Which informational text is easier to understand and why?"

Activity 3- Demonstration of Knowledge

During this lesson, students will produce a product to demonstrate their understanding of using text features for research. The product will contain one of the five astronomers presented to the students. The astronomers chosen come from a variety of cultural backgrounds and historical time periods. Students will include information about the astronomer's life and their professional contributions to astronomy.

Day 1 – 5

Students will work in pairs and individually to complete this research project. As students research the astronomer they have chosen or have been assigned, they will use various sources to obtain the required information. As they read the materials, students will take notes that will be used to write their research paper. The astronomers chosen for students to research are Ptolemy, Galileo, Annie Jump Cannon, Subrahmanyan Chandrasekhar, and Neil deGrasse Tyson. Each one of these astronomers have made history in the field of astronomy or astrophysics.

Ptolemy, a Greek astronomer, created a geocentric model of the universe by observing the movement of the heavens. His model replicated the movement of the stars and planets. This model was the accepted model of the universe for 1,500 years. His greatest work was the Almagest which was a star catalogue, as well as an astronomy text which is divided into 13 books.

Galileo is a well-known Italian astronomer. He was known as the Father of Modern science. He invented the first refracting telescope by modifying a spyglass. With this invention he was able view the phases of the moon and its surface. With his telescope, he saw the rings around the planet Saturn, and he observed that Venus went through the same phases as the moon did. With the Telescope, Galileo was able to see individual stars and the empty space between them. In 1610, he discovered the four largest moons of Jupiter, Io, Europa, Ganymede, and Callisto, known as the Galilean moons. Because of his discoveries, Galileo began to believe in a Heliocentric / Sun Centered Universe.

Annie Jump Cannon was an American astronomer from the early 1900s. She was charged with taking photographs of the sky each night, which originally was men's work, and studying the stars in the photographs for their position and spectra. Between 1911 and 1915, she came up with a simpler system to classify the stars' spectral lines. The system ranked the stars from the hottest to coolest. The system she devised is still being used today. During this time, she cataloged approximately 250,000 stars. Her main contribution to astronomy was stellar spectral classification, which is based on the luminosity and temperature of a star. During her career at Harvard, Annie classified nearly 400,000 stars. She was honored with a Doctor of Science degree from Oxford University, and the Draper Medal of the National Academy of Sciences, the only woman to receive this award.

Subrahmanyan Chandrasekhar was a twentieth century astrophysicist from India. Chandrasekhar began to do research in astrophysics and became interested in what happens to stars as they age. In 1930, at the age of nineteen he created the Chandrasekhar Limit. This is the limiting mass "above which no stable white dwarf star can exist. "[37] The limit is 1. 4 solar masses. "A star that ends its nuclear-burning lifetime with a mass greater than the Chandrasekhar limit must become either a neutron star or a black hole. "[38] He published his work on the mathematical theory of black holes in 1983. He was finally rewarded for his work in 1983 when he was awarded the Nobel Prize on his work on stars and their evolution.

Neil deGrasse Tyson is a popular present-day American astrophysicist. He loves to educate the public about science, specifically about space. He is interested in supernovas. "He is also known for using ultraviolet (UV) photometry--the measurement of the intensity of UV light emitted by a celestial body--to study various phenomenon. Much of Tyson's research work focused on improving scientists' understanding of how stars and galaxies are formed. "[39]

Once students have completed their research, they will meet with other students who have been researching the same astronomer in order to share information and gather ideas for their presentation. Once students share their information, they will begin to work independently to produce their product. Students will use a graphic organizer to organize the information into categories. Students will fill in the graphic organizer with information about the astronomer's early life, their accomplishments, and interesting / fun facts.

Day 6-10 – Project and Presentation

For the next few days, students will work to complete their project. They will be able create a magazine article, a book, or a slide show to showcase what they have learned about the astronomer they researched. Students will need to include various text features to their report to enhance the text. The project will be presented to the class as an oral report. While the information is being presented to the class, the other students will be taking notes and formulating questions to ask the presenter. There will be a question and answer period at the end of each presentation.

Day 11-14 Extension

To extend student knowledge, have students will be given a copy of the night sky in the southern hemisphere. This page will only have the stars showing, the constellations and their names will not be included. Ask students to connect the dots to create a picture of something and then give it a name. When they have finished with their picture, have them write a short story, folktale or pourquoi about their picture. Students will share the stories with their partners and get feedback. Explain to the students that even before Ptolemy's time, people were looking at the night sky and creating pictures of mythical heroes or beasts and used those pictures called constellation to tell stories about those heroes. Show students a picture of the night sky with the constellations. Pick out a few constellations, like Orion or Pegasus.

To further extend the lesson, students can watch a video on Galileo, or listen to one of Neil deGrasse Tyson's podcasts. Students can visit a planetarium, or if you do not have access to one, you can download the program Stellarium. Stellarium is a free planetarium program that you can download to your computer. It shows a realistic sky as seen with the naked eye or a telescope. Have students take a trip through the history of astronomy. They can observe the night sky as Ptolemy saw it with his eyes. They can view the planet Jupiter and the four largest moons just like Galileo did through his telescope. Students can compare the brightness of stars. They can also watch the lifespan of a star and visit a black hole, or see nebulas the way Neil deGrasse Tyson does with pictures from the Hubble.

Appendix

Literacy

Five Common Core State Standards will be covered in this unit. The first standard is RI5. Students will be using text features and search tools to locate information relevant to a given topic efficiently. Standard RI3 has students describing the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text using language that pertains to time, sequence, and cause/effect. For Standard RI9 students will compare and contrast the most important points and key details presented in two texts on the same topic.

The writing standards covered in this unit are W8 which has students recalling information from experiences or gathering information from print and digital sources, taking brief notes on sources and sorting evidence into provided categories. Finally, Standard W2 has students writing informative/explanatory texts to examine a topic and convey ideas and information clearly.

Bibliography

American Museum of Modern History. n. d. *Ology:Being an Astronomer: Neil deGrasse Tyson.* Accessed October 28, 2018. https://www. amnh. org/explore/ology/astronomy/being-an-astronomer-neil-degrasse-tyson. Interview with Neil deGrasse Tyson

Association, National Earth Science Teachers. 2012. *Windows to the Universe - Astronomy Timeline.* Accessed October 14, 2018. https://www. windows2universe. org/the_universe/uts/timeline. html. Timeline of the history of astronomy

Ball, R. S. 2000. "Great Astronomers. " In *Great Astronomers*, by R. S. Ball, 458. The Project Gutenberg eBook. Information on Ptolemy and Galileo

BBC. 2014. *How do telescopes let us see so far into space?* June 18. Accessed October 24, 2018. http://www. bbc. co. uk/science/0/20937803. Explains how telescopes work

Bennett, Jeffery. 2017. "Telescopes: Portals of Discovery. " In *The Cosmic Perspective*, by Jeffrey Bennett, 168. Boston: Pearson. Explains the properties of telescopes

Bennett, Jeffrey. 2017. "The Cosmic Perspective. " In *The Cosmic Perspective*, by Jeffrey Bennett, 61, 63, 103. Boston: Pearson. Discusses early astronomy and the tools used.

Biography. com Editors. 2014. *The Biography. com website.* April 2. Accessed October 28, 2018. https://www. biography. com/people/neil-degrasse-tyson-20766239. Biographical information on Neil deGrasse Tyson.

Book, World. 2018. *Chandrasekhar, Subrahmanyan.* Accessed October 28, 2018. www. worldbookonline. com/kids/home#article/ar834935. Biographical information on astrophysicist Chadrasekhar

Britannica, Editors of Encyclopedia. n. d. *Uraniborg Observatory Denmark.* Accessed October 23, 2018. https://www. britannica. com/topic/Uraniborg. Information on the observatory established by Tycho Brahe

Brittanica, The Editors Encyclopedia. n. d. *Astronomical Observatory.* Accessed October 22, 2018. https://www. britannica. com/science/astronomical-observatory. Information on what an astronomical absevatory is and how they work.

Center, San Diego Super Computer. n. d. *Annie Jump Cannon Theorist of Star Spectra.* Accessed October 28, 2018. https://www. sdsc. edu/ScienceWomen/cannon. html. Biographical information on astronomer Annie Jump Cannon

CNX, OpenStax. 1999-2018. *Astronomy.* Accessed October 21, 2018. https://cnx. org/contents/LnN76Opl@10. 1:D6EvmGmR@3/The-Birth-of-Modern-Astronomy. Information on how modern astronomy developed with the invention of the telescope

Context, Research in. 2006. *Subrahmayan Chandrasekhar.* Accessed October 28 , 2018. https://link. galegroup. com/apps/doc/K2641500250/MSIC?u=dove10524&sid=MSIC&xid=9af6d22b. Biographical information on astrophysicist Chandrasekhar

2009. In *Mad About Rockets Stars and Outer Space*, by Sarah Creese, 24. Make Believe Ideas. Nonfiction book on astronomy for children

Editors, Biography. Com. 2014. *The Biography. com Website.* April 2. Accessed October 27, 2018. https://www. biography. com/people/galileo-9305220. Biographical information on Galileo

Encyclopaedia Britannica. 2017. "10-Minute Guide Space Your Guide to the Universe. " In *10-Minute Guide Space 10-Minute Guide Space*, by Encyclopaedia Britannica, 44-45. Morton Grove, IL: Publications International. Various information about the solar system and space.

Encyclopedia Britannica. 2010. "Astronomical Observations: Astronomy and the Study of Deep Space. " In *Astronomical Observations: Astronomy and the Study of Deep Space*, by Enclyclopedia Britannica, 586. Rosen Educational Services. Information on stars and telescopes

Eric Gregersen. 2010. *Infrared Telescope.* March 15. Accessed October 27, 2018. https://www. britannica. com/science/infrared-telescope. Information on how an infrared telescope works and what observatories have them.

2014. *Famous Scientists Subrahmanyan Chandrasekhar.* November 2. Accessed October 28, 2018. https://www. famousscientists. org/subrahmanyan-chandrasekhar/. Biographical information on Chandrasekhar

Finley, Michael John. n. d. *Mayan Astronomy.* Accessed October 21, 2018. http://ircamera. as. arizona. edu/NatSci102/NatSci/text/extmayaastronomy. htm. Information on the history of Mayan astronomy

Gerber, Carole. 2011. "Annie Jump Cannon, Astronomer. " In *Annie Jump Cannon, Astronomer*, by Carole Gerber. Gretna, Louisiana: Pelican Publishing. Children's book on the life and professional career of Annie Jump Cannon

2018. In *The Planets*, by Gail Gibbons, 32. Holiday House. Children's book about the planets

Hamilton, Calvin J. 1997-2009. *Views of the Solar System.* Accessed October 27, 2018. http://solarviews. com/eng/galdisc. htm. Information on the discovery of the Galilean satellites

2000. In *Mysteries of the Universe*, by Nigel Hawkes. Copper Beech Books. Children's book on the universe.

History, Canadian Museum of. n. d. *Maya Civilization.* Accessed October 21, 2018. https://www. historymuseum. ca/cmc/exhibitions/civil/maya/mmc07eng. shtml. Information on astronomy and the Mayan Civilization

Kids Discover. n. d. "Sun. " *Kids Discover*, 20. Informational magazine on the sun

Kids Discover Magazine. 1994. "Solar System. " *Kids Discover* , June: 20. Informational magazine on the solar system

Kids Discover. 2001. "Moon. " 20. Informational magazine on the moon

Kids, Britannica for. 2018. *Subrahmanyan Chandrasekhar.* Accessed October 28, 2018. https://kids. britannica. com/students/article/Subrahmanyan-Chandrasekhar/310640. Biographical information on Chadrasekhar

Kortemartin, Keith. n. d. "Galileo. " In *Galileo*, by Keith Kortemartin, 16. Learning A-Z. Children's informative text on Galileo's life.

Layden, Andrew. 2002. *Telescopes: Angular Resolution and "Seeing".* November. Accessed October 27, 2018. https://physics. bgsu. edu/~layden/Anim/Telescopes/Seeing/seeing. htm. Information on how telescopes work and how they are used.

MANSUROV, NASIM. n. d. *What is Chromatic Aberration?* Accessed October 24, 2018. https://photographylife. com/what-is-chromatic-aberration. Information on optical problems with lens and wavelengths of color

NASA Goddard Space Flight Center. 2013. *Imagine the Universe X-Ray Telescopes.* September. Accessed October 27, 2018. https://imagine. gsfc. nasa. gov/science/toolbox/xray_telescopes1. html. Information from NASA on the use of X-Ray telescopes

Network, Kids Know It. 2018. *Kids Astronomy.* Accessed October 24, 2018. https://kidsastronomy. com/space-exploration/telescope-timeline/. History of the telescope for children

Oregon, University of. n. d. *History of Astronomy.* Accessed October 7, 2018. http://abyss. uoregon. edu/~js/ast121/lectures/lec02. html. Follows the history of astronomy from early man through Issac Newton in the 1680's

Project, Theoi. 2000-2017. *Star Myths.* Accessed 12 16, 2018. http://www. theoi. com/greek-mythology/star-myths. html. Explains the mythology behind the stories of the constellations.

2014. In *Our Sun*, by William B. rice, 24. Teacher Created Materials. Children's book about the sun

Rodgers, Nigel. 2010. "Everyday Life in Ancient Greece People and Places. " In *Everyday Life in Ancient Greece People and Places*, by Nigel Rodgers, 200-203. London: Hermes House. Information on Ptolemy, Hipparchus, and other Greek astronomers.

School of Mathematics and Statistics University of St Andrews, Scotland. 1999. *Hipparchus of Rhodes.* April. Accessed October 14, 2018. http://www-groups. dcs. st-and. ac. uk/history/Biographies/Hipparchus. html. Biographical information about Hipparchus and his contributions to astronomy, mainly the precession of the equinoxes.

School of Mathematics and Statistics University of St. Andrews, Scotland. 1999. *Abu'l-Hasan Ali ibn Abd al-Rahman ibn Yunus.* November. Accessed October 14, 2018. http://www-history. mcs. st-and. ac. uk/Biographies/Yunus. html. Biographical information on the astronomer Ibn Yanus.

—. 1999. *Claudius Ptolemy.* April. Accessed October 27, 2018. http://www-groups. dcs. st-and. ac. uk/history/Biographies/Ptolemy. html. Information on Ptolemy and his contributions to astronomy.

Scientists, Famous. 2016. *Claudius Ptolemy.* August 27. Accessed October 27, 2018. https://www. famousscientists. org/claudius-ptolemy/. Information on Ptolemy's Almagest which included tables that predicted the location of any heavenly body.

Shea Hopkins. n. d. *LearnZillion: Add Text Features to Informational Writing.* Accessed 12 8, 2018. https://learnzillion. com/assignments/A6DT857. On-line lesson to teach text features.

Shuttleworth, Martyn. 2018. *Ancient Astronom, Science and the Ancient Greeks.* Accessed October 14, 2018. https://explorable. com/greek-astronomy. Explains how the Greeks helped to develop western astronomy and science.

—. 2018. *Explorable Indian Astronomy in the First Millennium.* Accessed October 21, 2018. https://explorable. com/indian-astronomy. Explains about the works of the Indian astronomers and how exchanging their findings with the people who used the silk road, helped to develop the science of astronomy.

—. 2018. *Explorable, Egytian Astronomy.* Accessed October 14, 2018. https://explorable. com/egyptian-astronomy. Explains about the early Egyptian astronomers and their influence on astronomy

Springfield Public Schools. n. d. *District 186 Digital Literacy.* Accessed 12 8, 2018. http://www. sps186. org/schools/techservices/digital_literacy/?p=92728. Information about the various digital text features.

Staff, Soderman. NLSI. n. d. *NASA, Solar System Exploration Research Virtual Institute.* Accessed October 14, 2018. https://sservi. nasa. gov/articles/oldest-lunar-calendars/. Information on early man and their knowledge of the phases of the moon and creating a lunar calendar.

Stellarium. n. d. *Stellarium.* Accessed 12 15, 2018. https://stellarium. org/. Planetarium program that shows you what you see in the sky

1994. In *I Wonder Why Stars Twinkle*, by Carole Stott, 32. Kingfisher. Children's book explaining about stars and what they are

Student Resources in Context. 2017. *Neil deGrasse Tyson.* Accessed October 28, 2018. https://link. galegroup. com/apps/doc/K1618006694/SUIC?u=dove10524&sid=SUIC&xid=504198c6. Biographical information on astrophysicist Neil deGrasse Tyson

Teacher Created Materials. 1994. "Annie Jump Cannon. " In *Focus on Scientists*, by Teacher Created Materials, 14-16. Huntington Beach, California: Teacher Created Materials. Biographical information on astronomer Annie Jump Cannon

Teacher Created Materials. 1994. "Galileo Galilei. " In *Focus on Scientists*, by Teacher, 23-25. Huntington Beach, CA: Teacher Created Materials. Biographical information on astronomer Galileo

Team, The StarChild. n. d. *Subrahmanyan Chandrasekhar.* Accessed October 27, 2018. https://starchild. gsfc. nasa. gov/docs/StarChild/whos_who_level2/chandra. html. Information on astrophysicist Chandrasekhar and his contributions to astronomy.

United Nations Education, Scientific, and Cultural Organization. 2010. *Helwan Observatory*. March 11. Accessed October 14, 2018. https://whc. unesco. org/en/tentativelists/5574/. Information about the Helwan Observatory in Egypt that was built in the early 1900's and was the first telescope to record Halley's Comet in 1909 and 1911.

University, Astronomy Department at Cornell. 2018. *Ask an Astronomer.* Accessed 10 7, 2018. http://curious. astro. cornell. edu/people-and-astronomy/the-history-of-astronomy. The history of astronomy from early man to Galileo

Virk, Zakaria M. n. d. *A Brief History of Observatories in the Islamic World (800-1600).* Accessed October 14, 2018. http://www. academia. edu/6431427/A_Brief_History_of_Observatories_in_the_Islamic_World_800-1600_. Explains the history of observatories in the Middle East from 800-1600

Weiser-Alexander, Kathy. 2018. *Legends of America: Exploring history, destinations, people, & legends of this great country since 2003.* Accessed October 8, 2018. https://www. legendsofamerica. com/na-astronomyculture/. Information on early North American indigenous tribes and archaeastronomy

Wisdon, Ancient. n. d. *Precession of the Equinoxes.* Accessed 12 15, 2018. http://www. ancient-wisdom. com/precession. htm. Explains what the precession of equinoxes is.

1996. In *Eyes on Adventure Exploring Space,* by Leigh Hope Wood, 29. Kidsbooks, Inc. Children's book about space.

Notes

[1] SSERVI, https://sservi.nasa.gov/articles/oldest-lunar-calendars/, accessed October 14, 2018

[2] Windows to the Universe, The Stonehenge Monument, https://www.windows2universe.org/the_universe/uts/timeline.html, accessed October 14, 2018

[3] History of Astronomy, http://abyss.uoregon.edu/~js/ast121/lectures/lec02.html, accessed October 7, 2018

[4] History of Astronomy, http://abyss.uoregon.edu/~js/ast121/lectures/lec02.html, accessed October 7, 2018

[5] University, Astronomy Department at Cornell, http://curious.astro.cornell.edu/people-and-astronomy/the-history-of-astronomy, accessed October 7, 2018 (Oregon n.d.)

[6] Shuttleworth, Martyn, https://explorable.com/indian-astronomy, accessed October 21, 2018

[7] Shuttleworth, Martyn, https://explorable.com/indian-astronomy, accessed October 21, 2018

[8] Finley, Michael John, http://ircamera.as.arizona.edu/NatSci102/NatSci/text/extmayaastronomy.htm, accessed October 21,2018

[9] Canadian Museum of History, https://www.historymuseum.ca/cmc/exhibitions/civil/maya/mmc07eng.shtml, accessed October 21, 2018

[10] Canadian Museum of History, https://www.historymuseum.ca/cmc/exhibitions/civil/maya/mmc07eng.shtml, accessed October 21, 2018

[11] Shuttleworth, Martyn, https://explorable.com/greek-astronomy, accessed October 14, 2018

[12] Rodgers, Nigel. 2010. "Everyday Life in Ancient Greece People and Places." In *Everyday Life in Ancient Greece People and Places*, 256.

[13] Shuttleworth, Martyn, https://explorable.com/greek-astronomy, accessed October 14, 2018

[14] School of Mathematics and Statistics University of St. Andrews, Scotland. 1999. (. Accessed October 14, 2018) *Abu'l-Hasan Ali ibn Abd al-Rahman ibn Yunus.* http://www-history.mcs.st-and.ac.uk/Biographies/Yunus.html.

[15] Wisdom, Ancient, http://www.ancient-wisdom.com/precession.htm, accessed December 115,2018

[16] Shuttleworth, Martyn, https://explorable.com/greek-astronomy, accessed October 14, 2018

[17] Shuttleworth, Martyn, https://explorable.com/egyptian-astronomy, accessed October 14, 2018

[18] Weiser-Alexander, https://www.legendsofamerica.com/na-astronomyculture/, accessed October 8, 2018.

[19] Britannica Encyclopedia, https://www.britannica.com/science/astronomical-observatory, accessed October 22, 2018

[20] Britannica Encyclopedia, https://www.britannica.com/science/astronomical-observatory, accessed October 22, 2018

[21] Britannica Encyclopedia, https://www.britannica.com/topic/Uraniborg, accessed October 23, 2018

[22] Bennett, Jeffery. 2017. "Telescopes: Portals of Discovery." In *The Cosmic Perspective*, 168.

[23] Photography Life, https://photographylife.com/what-is-chromatic-aberration, accessed October 24, 2018

[24] Bennett, Jeffery. 2017. "Telescopes: Portals of Discovery." In *The Cosmic Perspective*, 168.

[25] Bennett, Jeffery. 2017. "Telescopes: Portals of Discovery." In *The Cosmic Perspective*, 168.

[26] Eric Gregersen. *Infrared Telescope.* March 15, 2010 (Accessed October 27, 2018) https://www.britannica.com/science/infrared-telescope.

[27] NASA Goddard Space Flight Center. *Imagine the Universe X-Ray Telescopes.* September 2013 (Accessed October 27, 2018). https://imagine.gsfc.nasa.gov/science/toolbox/xray_telescopes1.html.

[28] Scientists, Famous *Claudius Ptolemy.* August 27, 2016 (Accessed October 27, 2018). https://www.famousscientists.org/claudius-ptolemy/.

[29] Hamilton, Calvin J. 1997-2009. *Views of the Solar System.* Accessed October 27, 2018. http://solarviews.com/eng/galdisc.htm.

[30] American Museum of Modern History, *Ology:Being an Astronomer: Neil deGrasse Tyson.* (Accessed October 28, 2018). https://www.amnh.org/explore/ology/astronomy/being-an-astronomer-neil-degrasse-tyson.

[31] Center, San Diego Super Computer, *Annie Jump Cannon Theorist of Star Spectra.* (Accessed October 28, 2018). https://www.sdsc.edu/ScienceWomen/cannon.html.

[32] Gerber, Carole. 2011. "Annie Jump Cannon, Astronomer." In *Annie Jump Cannon, Astronomer*, 23

[33] Encyclopaedia Britannica. 2017. "10-Minute Guide Space Your Guide to the Universe." In *10-Minute Guide Space 10-Minute Guide Space*, by Encyclopaedia Britannica, 44

[34] Encyclopaedia Britannica. 2017. "10-Minute Guide Space Your Guide to the Universe." In *10-Minute Guide Space 10-Minute Guide Space*, by Encyclopaedia Britannica, 45.

[35] Student Resources in Context, *Neil deGrasse Tyson.* . 2017 (Accessed October 28, 2018). https://link.galegroup.com/apps/doc/K1618006694/SUIC?u=dove10524&sid=SUIC&xid=504198c6.

[36] Student Resources in Context, *Neil deGrasse Tyson.* . 2017 (Accessed October 28, 2018). https://link.galegroup.com/apps/doc/K1618006694/SUIC?u=dove10524&sid=SUIC&xid=504198c6.

[37] Encyclopaedia Britannica. 2017. "10-Minute Guide Space Your Guide to the Universe." In *10-Minute Guide Space 10-Minute Guide Space*, by Encyclopaedia Britannica, 44

[38] Encyclopaedia Britannica. 2017. "10-Minute Guide Space Your Guide to the Universe." In *10-Minute Guide Space 10-Minute Guide Space*, by Encyclopaedia Britannica, 45.

[39] Student Resources in Context, *Neil deGrasse Tyson.* . 2017 (Accessed October 28, 2018). https://link.galegroup.com/apps/doc/K1618006694/SUIC?u=dove10524&sid=SUIC&xid=504198c6.