• V I R T U A L •

Homeschool DAYS

Mission San Luis

17th Century SCIENCE

Scientific principles (rules or laws of science) are in action all around us in everyday life. They keep birds flying in the air, and make water wet! And we use scientific principles to do everyday things: to grow and cook our food, build our buildings, take care of the sick, and travel from one place to another. The ways we do things are all influenced by our scientific knowledge. Did people use science in Florida over 300 years ago? Of course! Science was just as important in the 1600s as it is today – even if the people of the past may have thought about it differently!

So, how is science defined in modern times? **Science is the careful study of the world to understand how it works.** Some sciences involve the study of life on Earth (like botany, zoology, and microbiology), while other sciences look at the different inorganic (non-living) processes that occur on the planet, and even in space (like physics, geology, and astronomy)! Sometimes, a science studies both living and non-living things on the planet: for instance, chemistry looks at the processes of both living organisms and the natural environment. Often, multiple sciences are involved in describing the processes on earth. The way people learn in ALL the sciences is by conducting experiments (or careful tests) and by making observations about the world. Although scientific principles are in action all around us everyday – whether we study them or not – we learn more about them by actually studying them in a careful manner.

People in the 17th century – including the Apalachee Indians and the Spanish who lived in the village of Mission San Luis in Northwest Florida – used many different types of "science" to accomplish everyday tasks. Sometimes, they would perform science almost like we do today to learn more about the world. They would select a scientific question or problem that needed to be answered, carefully study the world related to the question or problem, make observations, and keep track of what they found. Some important discoveries about science were made in this way! Science was sometimes studied in universities in Spain and by explorers who came to the "New World" of the Americas (including Florida). Science was also studied by some of the Spanish friars (priests) who came to Florida. Some Aplachee Indians also made many careful observations about the world, as well.

◀ *Friary in the apothecary, 1529*
http://blog.wellcomelibrary.org/2016/01/the-medicine-of-the-friars-in-late-medieval-england/

But learning about and using science in the past was not always as formal as a scientific study today. Often, people figured out how to use scientific principles by just practicing them in their everyday lives. For example, if someone wanted to improve on how something was done (like an Apalachee Indian farmer who wanted to grow healthier crops), they tried a new way of doing the

task until they found a solution that helped them do it better (like finding a way to do or add something that would make the garden soil richer)! Often, they were trying to understand the world using scientific principles that they could not identify or see. For instance, they did not have the technology or scientific knowledge to know that garden soil is better if you add nutrients to it: they just knew that if they did certain things to the soil (like planting different crops at certain times of the year), bigger crops would be produced.

Even if people were not carefully conducting scientific experiments and documenting their conclusions, or did not know why things were happening, they could still make useful discoveries that were passed down from generation to generation. Most of the scientific knowledge we know today has developed from this generational knowledge learned in the past!

Often, both the Spanish and the Apalachee Indians combined science with mythology and religion. In other words, they sometimes explained the way the world worked using their cultural and spiritual beliefs and traditions. For instance, in the 1500s many in Spain believed that different or strange creatures – and even monsters and mythical animals – lived in distant lands. So when the Spanish first began traveling to the Americas (including Florida) in the early 1500s, some thought they would find these creatures in the New World. This shaped their knowledge of animals and the types of animals they thought they would find. Of course, they did find a lot of new animals when they reached Florida, and immediately began trying to describe them. In some ways, they were trying to classify animals (or organize them by type) to better understand them. Let's see how Álvar Núñez Cabeza de Vaca, who traveled with the Spanish explorer Pánfilo de Narváez, described an opossum he saw in Florida in 1528:

"[an animal] which carried its young in a pouch on its belly until they are big enough to find food by themselves; but, even then, if someone approaches while they are foraging, the mother will not run before the little ones get into her pouch...."

He was making observations about his world and writing them down, like a scientist does!

Opossum and her babies
US National Park Service, Missouri Department of Conservation, Jim Rathert

Today, new scientific knowledge and technology allows us to understand more about the many branches of science than people of the past could. For example, many people in the past believed that bad smells or bad odors in the air were the main reason that people became sick. A few people even thought that there might be a substance in the air that made people sick. Today, we now know that germs – some of the tiny "microorganisms" that live in the environment and on our bodies – can make us sick. And some of those microorganism do float in the air! (Although not all microorganism are bad: some bacteria HELP our bodies!). This means that we think of science in a different way than people of the past. But even though we have learned a lot more about science today, we can still appreciate and learn from the scientific discoveries that people of the past made!

Time Portal: Villagers through Video

Let's go back in time to talk with one of the villagers of Mission San Luis about science in 1703! Check out the video link below.

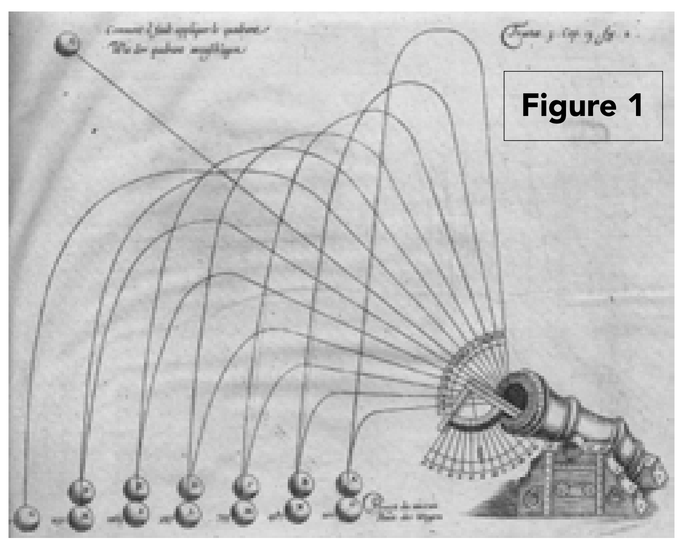
17th-Century Science Lesson Video Link: youtube.com/watch?v=1JgxWy6JvsU

Cannon Calculations: The Physics of Firing

People living in 17th Century Florida used many types of **technology** (using scientific knowledge for a practical purpose or to do everyday tasks)! Technology in the 1600's included the use of various tools and machines to complete many everyday tasks, like getting food or constructing buildings. Technology also consisted of the weapons used in wars and battles, such as the cannons used by Spanish soldiers in Florida!

Spaniards (and other Europeans) had been using cannons as weapons for protection and warfare for many years before bringing this technology to Florida. And they used science to make cannons work more effectively! Why did Spanish soldiers need science to fire a cannon? Couldn't they just put a cannonball into it and fire in the right direction to hit the target? Actually, no! It took careful scientific and mathematical calculations to make sure a cannonball hit its target – like the wall of an enemy fort.

Soldiers needed to aim the cannon so that the cannonball would (hopefully) land in the proper location. If they did not aim properly, they could not predict where the cannonball would land: it could hit the ground before reaching the target or completely fly over the target if it was shot too high. To aim a cannon, you need to use **physics** (the science that deals with how matter, energy, and motion work). Basically, physics sometimes involves the science of how objects move in the world, and the various types of energy that are needed to move them. Physics helped soldiers in the past figure out how a cannonball would move once shot out of a cannon.



1628 Diego Ufano engraving depicting cannonball trajectories

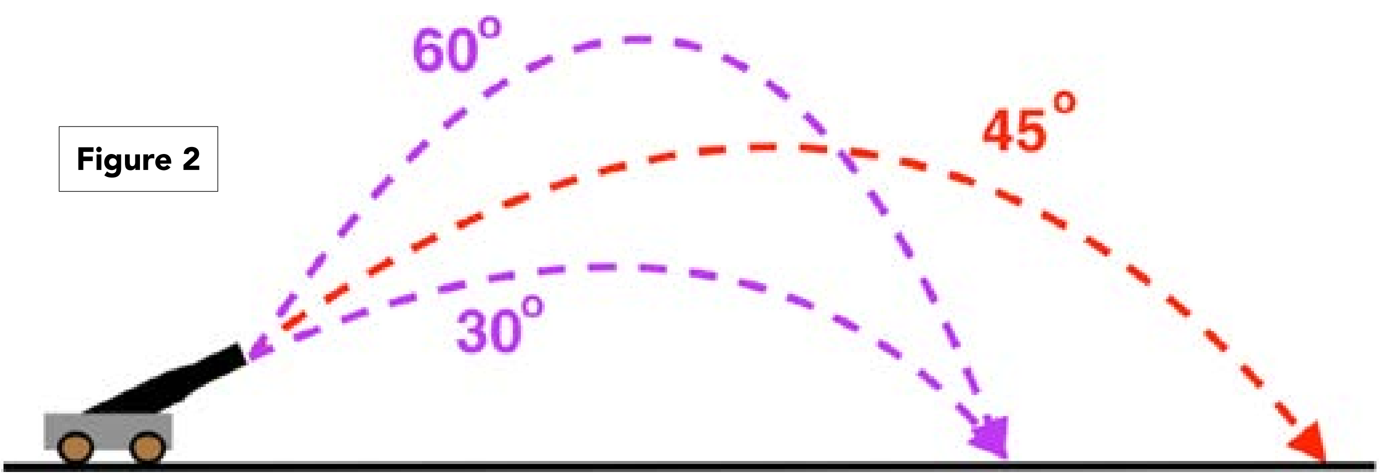
To properly aim a cannon, one must understand the law of universal gravitation – or the law of **gravity**. This law was published by **Sir Isaac Newton** in 1687 (during the time of Mission San Luis!). The law of gravity states that every particle in the universe attracts (or draws to it) every other particle in the universe with a force based on how close the particles are to each other and their mass (or the amount of material that an object is made of). In other words, if an object has a lot of mass (or a lot of substance), it has a stronger gravitational force to pull things toward it. Since the Earth is SO massive, it has a huge gravitational force that pulls smaller objects toward it. We see the Earth's gravity every day when things fall to the ground: like a cannonball after it has been shot from a cannon! The ball can't stay in the air forever: Earth's gravity will pull it back to the ground. To know how to aim and fire a cannon, one must first know when/how gravity will pull the cannonball to the ground.

Because of the law of gravity, we can predict where a cannonball will fall back to Earth. The cannonball will rise up and then fall back to Earth in a **parabolic shape** (U shaped, or an arc). This means firing the cannons at different **angles** (how high or low the open end of the cannon is in relation to the back/closed end) will make the cannonball fall at different spots. Angles are measured in degrees, indicated with the symbol **°**. Soldiers could figure out the best angle and position to arrange the cannon to fire the cannonball so that it flew in an arc to the correct distance. Notice that just because a cannonball flies higher at a greater angle doesn't mean it will land farther away! (Look at the 60° angle arch in Figure 2 below…even though the cannonball flies higher than one shot at a 30° angle, they land the same distance away. And it doesn't fly as far as with the 45° angle).

Once the 17th-century soldiers calculated what angle they needed to position the cannon, how did they know when they had properly moved the barrel (firing tube) of the cannon to the correct angle? Did they just eye-ball it and say, "That looks right!"? Most of the time, no! They used a tool called a **gunner's quadrant** to position the barrel of the cannon. (Do you see the triangular gunner's quadrant sticking out of the mouth of the cannon in Figure 1 on the previous page?) It measures the **elevation** (height) of the cannon barrel's open end. It is a like a ruler or protractor that measures angles. And once the position of the cannon barrel matched the correct angle on the gunner's quadrant, the soldiers knew they had positioned the cannon at the right angle to correctly fire it!

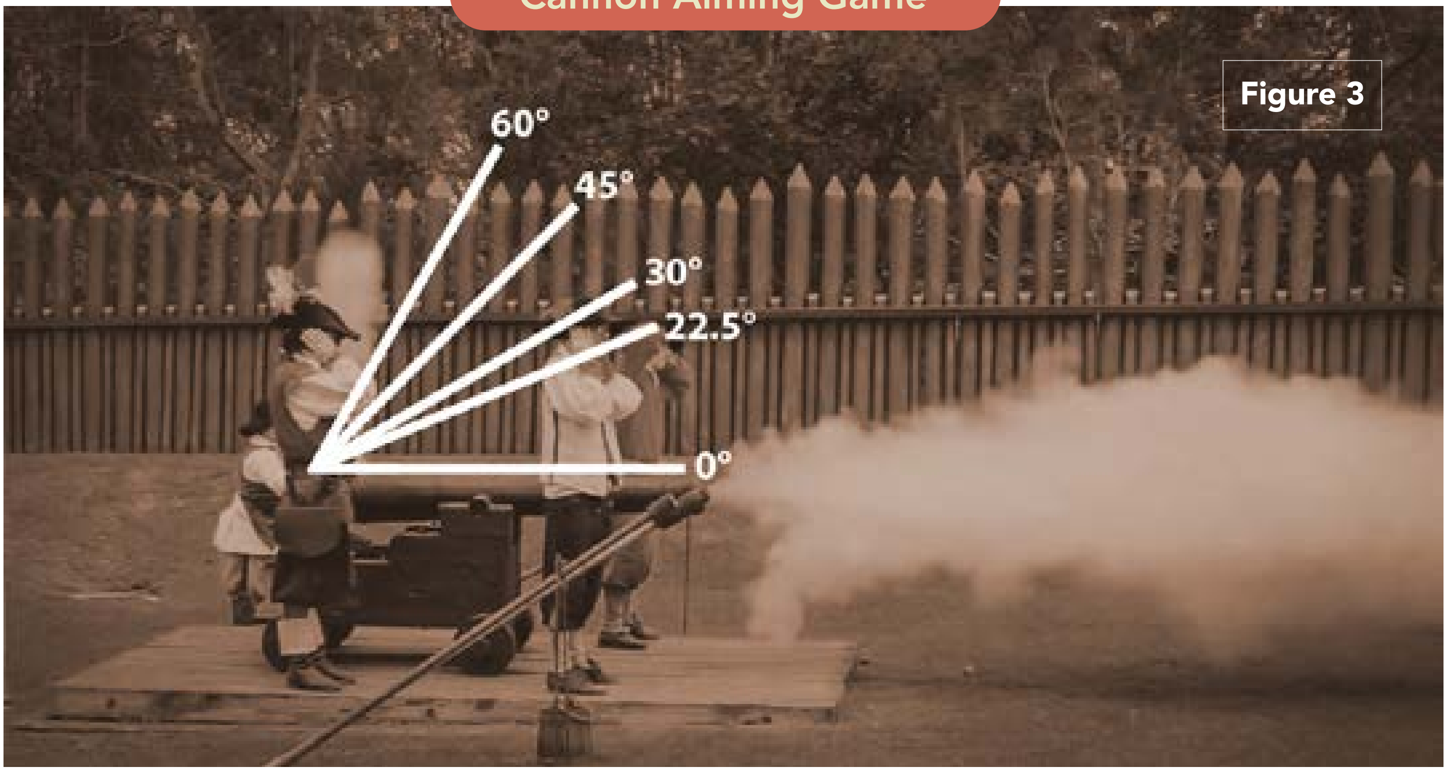
So, firing a cannon seems straight forward, right? Well, firing a cannon is more complicated than just finding the correct angle! The physics and angle descriptions discussed above are only general. All cannons and cannonballs were different, as well as the landscapes that a cannon was being fired in. A soldier would not get the exact same results even if they fired the same cannon or cannonball, nor would a firing always follow the rules listed above. There were also other factors to consider that affect where a cannonball lands during a firing: the amount of black powder in the cannon, the weather that day (was it rainy or windy?), if there were any obstacles blocking the cannonball, etc. But by using physics to aim, the soldiers could usually get pretty close to hitting their target!

Figure 2



[from https://www.khanacademy.org/science/high-school-physics/two-dimensional-motion-2/projectiles-launched-at-an-angle-2/a/projectiles-launched-at-angles]

Cannon Aiming Game



Let's see if you can help the soldiers at Mission San Luis aim a cannon. Look at Figure 3 above with the angles of the cannon marked, and help the soldiers determine the correct angle they need to position the barrel of the cannon for the following situations.

Calculations:

1. The soldiers want to fire the cannon <u>straight ahead</u> and it doesn't have to go very far. What angle should the barrel of the cannon be at for firing in a straight line in front of them? ______

2. Now the soldiers want to shoot the cannonball <u>as far as they can</u>. What angle is best for firing the cannonball the farthest? ______

(Look at Figure 2 on the previous page if you need a hint).

3. The soldiers now need to fire a cannon <u>over a line of trees</u>. Should they fire at a 30° or a 60° angle? ______

(Hint: the cannonball will land in the same area, but which angle will make the cannonball fly higher over the trees? Look at Figure 2 on the previous page if needed).

4. Okay, for the next shot the soldiers do not need to fire the cannonball as far as it can go, but it does need <u>to go some distance</u>. They need to fire it at an angle <u>halfway between 0° and 45°</u>. What angle should they position the cannon this time? ______

(Hint: divide 45 by 2)

Surprising 17th Century Technology

Did people in the 1600's use technology (see definition on page 3) like tools and machines to make their jobs easier? They sure did!

Tools are usually hand-held devices used to do a particular task (i.e., a hammer is a tool, and it is used specifically to drive nails into wood). The Apalachee Indians had a special tool used to crack open hickory nuts. It consisted of two parts: a piece of wood light enough to handle but heavy enough to break the nut shells. Another hollowed-out piece of wood was used as a "bowl" to hold the nuts. The acceleration (speeding up) of the striking wood – plus the mass or heaviness – creates a force (the strength or energy) strong enough to break the hickory nuts' shells open. This is another example of **physics**! (See the definition of physics on page 3.) It's much easier to break open a hard nut using this striking-tool than just your hands!

Machines are items with a number of separate parts that use some type of energy or power and movement do certain tasks. Remember, machines do not have to be powered by electricity, like a modern kitchen blender or sewing machine. Some machines are powered by people! The cannon discussed on the previous page was a machine: it is a piece of equipment with multiple parts that needs power (human power!) to operate it. Soldiers prepare, load, aim, and fire the cannon. But what type of power actually thrusts the cannon ball out of the cannon barrel (tube)? Humans don't make that happen**, chemical laws** do. (Chemical laws are laws of nature from the science of **chemistry**, which is what substances are made of and how different substances react with one another). Once the black powder (explosive gunpowder) in the cannon is lit by fire, the powder releases A LOT of energy that forces the cannonball out of the tube. The black powder went through a chemical reaction (a change to a substance that involves rearranging it's chemical make-up) that released the energy stored inside it! That big release of energy was enough to push the heavy cannon ball out of the cannon barrel.

A 17th-century printing press – a device with different parts typically used to make books and pamphlets by pressing words with ink onto a piece of paper – was another machine that required people moving certain parts by hand to make it operate. A long handle turned a heavy wooden screw, which put downward pressure on wooden boards with the type and paper. Like the hickory-nut cracking tool, this machine could provide more force and helped printers do their job faster than doing it completely by hand! And the design borrowed from older technology used for pressing grapes for wine and olives for oil!

◀ ***Impressio Librorum (Book Printing), detail, circa 1580–1605***
Engraving by Theodoor Galle after a drawing by Jan van der Straet, c. 1550.
From the Nova Reperta (New Inventions of Modern Times), British Museum

Tool Technology Brain Teasers

1. Think about a <u>tool</u> that people use to do tasks today.

What tool did you pick? ______________________________

What item from the 17th century (over 300 years ago) do you think would have done the same job?

____

Why do you think so?____

____

2. Think about a <u>machine</u> that people use to do tasks today.

What machine did you pick? ____________________

What item from the 17th century do you think would have done the same job?

____

Why do you think so?____

____

3. Look at the image of an item below. It is made out of a large shell. This is an Apalachee tool used to help them farm by digging up the soil, so they can plant seeds!

Is there something people use today that would have done the same job as this Apalachee gardening tool?

____

4. Look at the image of the items below. They are balls made out of clay that are about 2-1/2 inches in diameter. Archaeologists who have studied these items believe the Apalachee may have used these tools to keep their food hot. They may have put these clay balls in the fire, let them get hot, and then dropped the hot clay balls into a pot of stew to warm it up!

Is there something people use today that would have done the same job as the Apalachee clay heating balls?

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The Science of Fabric Colors

When a person goes into a clothing shop now, they will see clothes of all colors. Bright oranges, vibrant yellows, warm reds and strong purples can be seen on shirts, pants, hats, and other pieces of clothing. How did those fabrics get such amazing colors? They were dyed! A **dye** is a type of colorful substance that changes the hue of materials. Dyes allow people to change a fabric from one color to another. Often, fabrics start off as white or another light color and then are dyed to give them a stronger color like brown or orange.

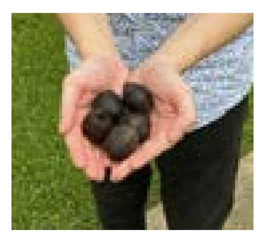
▲ *Naturally dyed fabric*
(from blackbirdfabrics.com)

In the 17th century, the villagers at San Luis would also use dyes when they wanted to change the color of their fabrics. All the dyes that were used at San Luis are what modern scientists would consider natural dyes. That means the dye comes from something in nature. For instance, the spice turmeric or onion skins can produce a yellow dye, mulberries can produce a pink dye, and red ochre (a type of clay coloring) could produce a red dye. These natural materials are harvested and properly prepared to make sure the dye stays in the fabric. In modern times scientists have discovered that the reason that the villagers were able to change the color of their fabrics was due to chemistry. As we discussed on page 6, chemistry is the field of science that deals with what substances are made of and how different substances react with one another.

When a villager at San Luis applied a dye to a piece of fabric, a chemical reaction took place. During the reaction, the dye **molecules** (groups of atoms attached together) bond to the fabric molecules, meaning that they stick together. Therefore, the color stayed in the fabric. The types of chemical bonds that happen with dyeing fabric are called **ionic** and **hydrogen** bonds. Ionic and hydrogen bonds are strong, but they are not that strong. Over time and through many processes (like when you wash your clothes!), the color will fade as the bonds weaken and break. One way to keep the dye molecules (and therefore the color) attached to the fabric longer is to use something called a **mordant**. Mordants are substances whose molecules come between the dye molecule and the fabric molecule, making a new type of bond. The bond that the mordant makes is called a covalent bond and it is stronger than the ionic or hydrogen bond. Because the bond is stronger, the dye will "stick" to the fabric for much longer. Many different materials were used as mordants in the past, including salts and some vinegars.

▲ *Hickory nut tree*

One of the most common dyes at San Luis was probably made from hickory nuts. Hickory trees can produce many nuts, which could be harvested for their meat (the edible part of the nut). Once the meat was harvested, the leftover shells were boiled down into a concentrate that could be used as a light to dark brown color depending on how strong the dye was. The reason that these shells make a brown color is due to the **tannins** (certain chemicals found in some plants) in the shells escaping into the water. It was said that the friar's robes were most likely colored using this hickory nut dye. If the person making the dye continued to concentrate (boil down) the substance and then added some more materials, it could even be used as an ink!



▲ *Hickory nuts*

Hickory Nut Dyeing Craft

You can dye your own fabrics using hickory nuts following the instructions below!

[Not suggested for those with a nut or tree nut allergy]

Directions:

1. Find fabric or clothes that you want to be dyed (basic linen fabric works best!) Make sure you have your parent or guardian's permission to dye the fabric

2. Collect about 1 gallon of hickory nuts (about two grocery bags worth).

3. Place all of the hickory nuts in a large pot that will not be used to cook food in the future.

4. Add at least 3 gallons of water to the hickory nuts (3:1 ratio).

5. Place the pot on a stove. (Make sure to ask a parent or guardian for help using the stove.)

Simmer the hickory nut mixture (uncovered) for 7 hours on low heat, adding a cup of water each time the water level falls below the hickory nuts. Check the pot periodically to make sure the water does not boil dry. This process allows the hickory nut pigment to be "**leached"** (drawn out or removed) from the nuts.

6. Now you should have a concentrated dye!

7. Mix 1 part vinegar to 4 parts water and then add the mixture to the dye concentrate.

8. Once the dye has been mixed with the vinegar and water, **place the fabric you want dyed in the pot. Simmer the fabric for a few hours on low heat**, allowing all the dye to soak into the fabric. The longer you leave the fabric in the dye, the darker the fabric will be. But the color will be lighter after it dries.

9. Rinse fabric until dye begins to clear from water. Start with warm water and gradually use cooler rinse water. *(Optional: use a commercially made dye fixative after dyeing and before washing to enhance color and reduce bleeding.)*

10. Dry the fabric by hanging outside on a clothes hangar,

Voila! Your fabric is now dyed and ready for use!

Additional Resources

Your time travel adventure doesn't stop here! If you want to learn more about this subject, here are some suggested resources:

- *Mission San Luis de Apalachee: A Teacher's Guide (Illustrated)*
  https://www.missionsanluis.org/media/1099/01-teachers_guide.pdf
- *Science Year by Year: A Visual History, from Stone Tools to Space Travel (Smithsonian)*
  https://www.google.com/books/edition/Science_Year_by_Year/Vq78DQAAQBAJ?hl=en&gbpv=0
- *Timucua Technology Lesson Series (Florida Public Archaeology Network)*
  https://fpan.us/resources/timucuan/
- *More Than Moccasins: A Kid's Activity Guide to Traditional North American Indian Life (Laurie M. Carlson)*
  – See how many types of science Native Americans used when creating everyday items!
  https://www.google.com/books/edition/More_Than_Moccasins/bMTxE8SmxrkC?hl=en&gbpv=0
- *The Story of Science (Anna Claybourne)*
  https://www.google.com/books/edition/The_Story_of_Science/sldPPQAACAAJ?hl=en
- *Christopher Columbus and the Age of Exploration for Kids: With 21 Activities (Ronald A. Reis)*
  – Explore the science of exploration!
  https://www.google.com/books/edition/Christopher_Columbus_and_the_Age_of_Expl/CTbVAAAAQBAJ?hl=en&gbpv=0
- *Colonial History Bibliography for Young Readers (Museum of Florida History)*
  https://museumoffloridahistory.com/learn/colonial-history-bibliography-for-young-readers/

Sunshine State Standards that may apply to this lesson:

Grade 4

Science

- SC.4.E.6.3: Recognize that humans need resources found on Earth and that these are either renewable or nonrenewable.
- SC.4.E.6.5: Investigate how technology and tools help to extend the ability of humans to observe very small things and very large things.
- SC.4.N.1.3: Explain that science does not always follow a rigidly defined method ("the scientific method") but that science does involve the use of observations and empirical evidence.
- SC.4.N.1.8: Recognize that science involves creativity in designing experiments.
- SC.4.N.2.1: Explain that science focuses solely on the natural world.
- SC.4.E.6.6: Identify resources available in Florida (water, phosphate, oil, limestone, silicon, wind, and solar energy)
- SC.4.N.1.2 Compare the observations made by different groups using multiple tools and seek reasons to explain the differences across groups.
- SC.4.P.9.1 Identify some familiar changes in materials that result in other materials with different characteristics, such as decaying animal or plant matter, burning, rusting, and cooking.
- SC.4.P.10.1: Observe and describe some basic forms of energy, including light, heat, sound, electrical, and the energy of motion.
- SC.4.P.10.2: Investigate and describe that energy has the ability to cause motion or create change.
- SC.4.P.12.1: Recognize that an object in motion always changes its position and may change its direction.

Social Studies

- SS.4.A.1.1: Analyze primary and secondary resources to identify significant individuals and events throughout Florida history.
- SS.4.A.3.1: Identify explorers who came to Florida and the motivations for their expeditions.
- SS.4.A.3.2: Describe causes and effects of European colonization on the Native American tribes of Florida.
- SS.4.A.3.4: Explain the purpose of and daily life on missions (San Luis de Talimali in present-day Tallahassee).

- SS.4.A.3.6: Identify the effects of Spanish rule in Florida.
- SS.4.A.3.7: Identify nations (Spain, France, and England) that controlled Florida before it became a United States territory.
- SS.4.A.4.1: Explain the effects of technological advances on Florida.

Reading/Language Arts:

- LA.4.1.6.1: The student will use new vocabulary that is introduced and taught directly.
- LA.4.5.2.3: The student will listen attentively to speakers and takes notes as needed to ensure accuracy of information.

Math:

- MAFS.4.G.1.1: Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.