Survival!

Exploration: Then and Now

Essential Question

What are the most essential items for the survival of settlers and explorers in new worlds?

Grade Level: 6–8

Connections to Curriculum:

Science and History

Teacher Preparation Time:

20 Minutes

Lesson Duration:

Two 50-Minute Class Periods

National Science Education Standards

Science as Inquiry

Science in Personal and Social Perspectives

Lesson Overview

This lesson introduces students to exploration and survival in new worlds. It compares challenges faced by explorers through the ages, checking for prior knowledge about conditions for survival in 1607 Jamestown and on the Moon.

During the **Explore** section, students are challenged to take on roles as explorers. Students are asked to choose items to help them survive in the Jamestown settlement in 1607. Items are ranked and choices are justified based upon meeting survival needs in this harsh environment.

During the **Extend** section, students take on the roles of astronauts who are part of a team landing on the Moon in 2025. Again, students are challenged to rank items for survival in this new world. Students compare the two survival challenges to develop a deeper understanding of exploration.

During the **Evaluate** section, students will revisit the **Essential Question** to identify common qualities of essential items for survival in 1607 Jamestown and future lunar settlements.

Upon completion of this lesson, students may want to know more about four themes of exploration: settlement, transportation, human needs, and the importance of water. These topics are developed in the four Web-based lessons included in the ***Exploration: Then and Now*** education module.

Background Information

Exploring new worlds is dependent on the survival of explorers and their ability to adapt to new environments. Rapid adaptation was critical for the early Jamestown settlers. Life in Virginia was much different than life in England. Conditions were harsh and the environment unfriendly. By 1609, nearly 500 English settlers had made the journey to Jamestown and the settlement seemed to be well established. By the winter of 1609 to 1610, conditions suddenly changed, leaving food and freshwater in short supply and only about 60 settlers alive.

Exploring worlds beyond Earth pushes survival to an entirely new level. In space and on other planets, fulfilling human needs presents great challenges. Survival requires adapting to new environments and finding solutions to new problems.

"Let us continue now with new explorations which are more expansive and more bold voyages which will define us as a space faring civilization."

—William Shepherd, Commander, Expedition 1, International Space Station

Instructional Objectives

Students will:

- analyze and rank items based upon their importance for survival in a particular environment;
- work as a team to come to a consensus about the importance of certain survival items;
- compare team rankings to rankings developed by history and astronomy experts;
- identify and compare human needs in two different exploration environments; and
- compare the differences in survival on Earth and the Moon.

Materials

Explore

Per student:

- "Survival in Jamestown Scenario"

Per group:

- "Survival in Jamestown Ranking Answer Key"
- "Survival in Jamestown Three-Circle Venn Diagram"

Extend

Per student:

- "Survival on the Moon Scenario"

Per group:

- "Survival on the Moon Ranking Answer Key"
- "Survival on the Moon Three-Circle Venn Diagram"

Instructional Procedure

Engage

1. Introduce the idea of exploration by discussing this quote with your students:

"Exploration is really the essence of the human spirit."

—Frank Borman, Commander, Apollo 8 Mission

2. As a class, continue the discussion of exploration by presenting these questions:

- Can anyone be an explorer? Name some past explorers. *(Accept a wide array of answers to help set the stage that everyone can be an explorer.)*
- Why do you think humans explore? *(Answers will vary.)*
- What are some of the limitations to exploration? *(Time, money, resources, etc.)*
- When might exploration lead to settlement? *(Settlements are established when there is sufficient food, water, shelter, space, climate, etc.)*
- What are some historical settlements and why were these sites chosen for settlement? *(There are a variety of answers. Be sure to include Jamestown, the first permanent English settlement in America.)*
- Where might future settlements be placed and why might these future sites be chosen? *(There are a variety of answers. Be sure to discuss that NASA plans to build settlements on the Moon.)*

Explore

Survival in Jamestown

1. Discuss the **Essential Question**: *What are the most essential items for the survival of settlers and explorers in new worlds?*
2. Ask students what they need to know before they can begin creating a list of essential items. The list of items is dependent upon the location and conditions of the new world.
3. This "Survival" challenge is based upon surviving in Jamestown in 1607. As a class, read and discuss the "Survival in Jamestown Scenario."

Student Handout

Survival in Jamestown Scenario

Survival in Jamestown Scenario

4. Ask students what they know about Jamestown and the environment the settlers chose for their new home after reading the scenario. Ask if students know anything more about Jamestown from prior reading or research. Help students organize this information in their journals using a chart similar to the chart below.

What do we know about Jamestown in 1607?	How would this affect survival?	What would I need to survive in this environment?
Example: The water was brackish.	It is unsafe to drink brackish water.	To survive, we need freshwater.

5. As a class, discuss how this environment would affect survival. For example, the site chosen for the Jamestown settlement was surrounded by brackish water. It is unsafe to drink brackish water. Continue the discussion by asking students what they might need to survive in these conditions. Help students organize this information in their journals.

Teaching Suggestion: *This lesson builds interest and motivation for students to want to learn more about exploration. A more in-depth study about exploration and survival in Jamestown in 1607 and possible lunar settlements can be found in the other four lessons in the* ***Exploration: Then and Now*** *education module.*

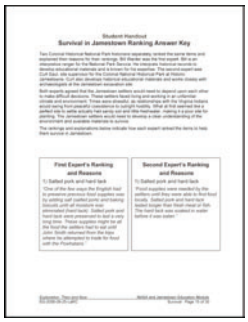
6. Assign students roles as 17th-century explorers. Ask them to imagine that they just spent 144 days at sea and have arrived at the location that will be known as Jamestown. The students' mission is to establish a permanent English settlement at this site.
7. Review the list of available items and discuss any items that might be unfamiliar. Inform the students that some of the images included are items that were actually found during archaeological digs. The artifact images are courtesy of the Colonial Historical National Park.
8. Ask students to independently rank the items listed from 1 to 15, identifying those items that would be most important for human survival in the harsh new environment at Jamestown. Items ranked with a low number (1 to 5) are the most valued. Items ranked with a high number (10 to15) are least valued. Students should write a one- or two-sentence reason for their rankings.

Teaching Suggestion: *You might put the image of each item on an index card and let the students sort and rank the items this way.*

9. Organize the students into small groups. After completing individual rankings, students will share their rankings with other members of the group and discuss their choices. Each team must agree upon a group ranking.

Teaching Suggestion: *Students could display their results with an electronic spreadsheet.*

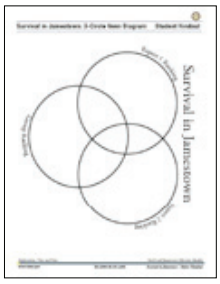
10. Ask each team to record their group rankings on an overhead transparency. Discuss the differences in the rankings and the reasons for the differences.
11. The Colonial Historical National Park historians developed two different rankings. Give each group a copy of both rankings and ask the group to analyze the differences between the historians' rankings and their group's rankings.



Survival in Jamestown Ranking Answer Key

Teaching Suggestion: *Discuss why there is <u>not</u> one correct ranking. Students should realize that the justifications and explanations for the rankings are more important than the numerical ranking. Explain that the "Ranking Answer Key" is based on historical and scientific information from the Colonial Historical National Park historians. The historians who developed the answer keys brought different expertise and understandings to the problem and were specifically asked to complete the rankings independently. Both historians agreed that they would have made different choices if they had worked as a team to rank the items.*

12. Have students work as a team on the "Survival in Jamestown Three-Circle Venn Diagram" to organize the rankings of the two historians and their own group ranking. Students may include any items that are scored plus or minus one number of their choices as an agreement. For example: One expert ranked the musket as number 2 and one ranked it as number 3. For the Venn Diagram, students should consider the musket ranking as an agreement. If the group ranked the musket as a 1, 2, 3, or 4, the item can be placed in the center section where all three circles intersect.



Survival in Jamestown Three-Circle Venn Diagram

Explain

1. As a class, identify items that were ranked the same by each group and the experts. Discuss possible reasons for this similar ranking.
2. Create a list of items that were ranked more than plus or minus one number different by the student groups and experts. Discuss possible reasons for these differences.
3. Identify information that the group was missing that would have helped them rank some of the items.
4. Ask students to read and respond to the following journal question individually.

Journal Prompt 1: Important decisions, such as survival decisions, may require teamwork and are often best decided by a group. Choose one item that you ranked differently than anyone in your group or differently than the historians. What were your reasons for the original ranking? What were the reasons the other person gave for a ranking that was different than your ranking? Would your reasons change now? How? Why? Before writing, set up a table to help organize and compare your ranking, your reasoning for the ranking, and the reasoning of the other person.

Extend

Survival on the Moon

1. Return to the **Essential Question**: *What are the most essential items for the survival of settlers and explorers in new worlds?* As a class, summarize some of the essential items for survival in Jamestown in 1607 and ask students if they think any items on this list would also be essential for survival on the Moon. The next "Survival" challenge is based upon surviving on the Moon in 2025.
2. As a class, read and discuss the "Survival on the Moon Scenario."

Student Handout
Survival on the Moon Scenario

Survival on the Moon Scenario

3. Ask students what they know about the Moon and the Moon's environment after reading the scenario. Ask if students know anything more about the Moon from prior reading or research. Help students organize this information in their journals using a chart similar to the chart below.

What do we know about the Moon?	How would this affect survival?	What would I need to survive in this environment?
Example: There is little or no oxygen on the Moon.	We need oxygen to live.	To survive, we need a source for oxygen.

4. As a class, discuss how this environment would affect survival. For example, there is little or no oxygen on the Moon. We need oxygen to live. Continue the discussion to help students understand what they might need to survive in these conditions. Help students organize this information in their journals.

Teaching Suggestion: *This lesson builds interest and motivation for students to want to learn more about exploration. A more in-depth study about exploration and survival on the Moon and possible lunar settlements can be found in the other four lessons in the* ***Exploration: Then and Now*** *education module.*

5. Assign students roles as 21st-century explorers who are establishing a settlement on the Moon. Ask students how their experience in ranking the items for survival in Jamestown might help with this challenge.
6. Review the list of available items. Inform the students that some of the images included are items that would *not* usually be found on the *Orion* spacecraft, but they may include them in their survival ranking. These items are included to see if students can determine their importance in the lunar environment. Discuss any items that might be unfamiliar to the students.
7. Ask students to independently rank the items listed from 1 to 15, identifying those items that would be most important for human survival in the harsh new environment of the Moon. Items ranked with a low number (1 to 5) are the most valued. Items ranked with a high number (10 to 15) are least valued. Students should write a one- or two-sentence reason for their rankings.

Teaching Suggestion: *You might put the image of each item on an index card and let the students sort and rank the items this way.*

8. Organize the students into small groups. After completing individual rankings, students will share their rankings with other members of the group and discuss their choices. Each team must agree upon a group ranking.

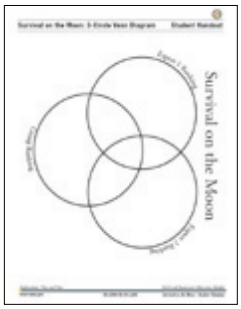
Teaching Suggestion: *Students could display their results with an electronic spreadsheet.*

9. Ask each team to record their group rankings on an overhead transparency. Discuss the differences in the rankings and the reasons for the differences.
10. Two NASA scientists developed two different rankings. Give each group a copy of both rankings. Carefully examine the reasons each expert gave for his response. Ask the group to analyze the differences between the experts' rankings and their group's rankings.

Survival on the Moon Ranking Answer Key

Teaching Suggestion: *Discuss why there is not one correct ranking. Students should realize that the justifications and explanations for the rankings are more important than the numerical ranking. Explain that the "Ranking Answer Key" is based on scientific information from NASA scientists. The scientists who developed the answer keys brought different expertise and understandings to the problem and were specifically asked to complete the rankings independently. Both scientists agreed that they would have made different choices if they had worked as a team to rank the items.*

11. Have students work as a team to complete a “Survival on the Moon Three-Circle Venn Diagram” to compare the results of the NASA experts to the group’s rankings. Students may include any items that are scored plus or minus one number of their choices as an agreement. For example: One expert ranked a magnetic compass as number 14 and one ranked it as number 15. For the Venn Diagram, students should consider the magnetic compass ranking as an agreement. If the group ranked the magnetic compass as a 13, 14, or 15, the item can be placed in the center section where all three circles intersect.



Survival on the Moon Three-Circle Venn Diagram

12. Ask students to reflect on the difficulty of each survival situation. Was the second “Survival” activity easier or more difficult than the first? Why? Relate the students’ experiences to explorers through the ages. *(New explorers learn from the experiences of those who have explored before them, but survival requires adapting to new environments and finding solutions to new problems.)*

Evaluate

1. As a class, discuss the following questions, drawing upon experiences from this lesson:

- Sir Isaac Newton is quoted to have said, “If I have seen further than others, it is because I have stood on the shoulders of giants.” How might this quote relate to explorers and settlers? *(Explorers and settlers learn from the experiences of others. The first people to travel or settle new worlds help pave the way for others to follow.)*
- What must explorers do *before* traveling to new worlds to prepare for their explorations? *(It is important to know about and prepare for the environment of the new world. It is also helpful to learn from the experiences of other explorers.)*
- What challenges do explorers face when they travel to new worlds? *(Explorers must be able to adapt to new environments and find solutions to new problems.)*
- What are the most essential items for the survival of settlers and explorers in new worlds? *(Some essential items are items that help settlers and explorers travel, navigate, find and store food, offer shelter, find and store water, protect themselves and their environment, etc.)*
- What are the benefits and difficulties in making decisions as a group? *(Group decision-making brings together more ideas and experiences to help solve a problem. It is sometimes difficult to build consensus and come to an agreement when working in a group.)*

2. Ask students to write a paragraph to respond to one of the following journal prompts.

Journal Prompt 2: What are the most essential items for the survival of settlers and explorers in new worlds? Organize your writing by thinking about answers to these questions:

- What do you need to know to survive in a new environment?
- What are the differences and similarities in items that are most valuable for survival in Jamestown and on the Moon? Compare and contrast.
- What are common qualities of these essential items for survival?
- What are common qualities of unessential items for survival?
- What can we learn about the basic needs of humans as new places are explored?

Journal Prompt 3: In addition to building a settlement on the Moon, NASA plans for humans to travel to Mars. Travel in space to Mars and beyond pushes the science of survival to a new level. Astronauts will encounter new problems that will require new solutions. Discuss what you think NASA will need to know and do before sending astronauts to Mars. Identify some items that would be essential for survival of settlers and explorers on Mars.

Teaching Suggestion: *This introductory lesson leads students to ask more questions about survival and exploration. Four more lessons are included in the educational module* ***Exploration: Then and Now*** *to help students learn more about four themes of exploration. These lessons will guide your students, as a class or independently, to find out more about:*

- *Transportation: How do vessel design, navigation, and propulsion affect exploration?*
- *Settlement: How do an area's location, soil, and weather affect settlement?*
- *Human Needs: How do people adapt to new environments? How will basic needs be met in new worlds?*
- *Follow the Water: Where is water found? Why is liquid water important for life?*

After your students study one or more of the other lessons in the ***Education: Then and Now*** *module, ask them to revisit the* ***Essential Question:*** *What are the most essential items for the survival of settlers and explorers in new worlds? Ask students to rank the essential items for survival again and compare the second ranking to the first to see if the students' additional knowledge about exploration changes their ideas about survival.*

Survival in Jamestown Scenario — Student Handout

You are a passenger on one of the three small, English, sailing ships captained by Christopher Newport in the spring of 1607. You are approaching the coast of Virginia after a long, wintry voyage across the Atlantic Ocean.

At first, you explore up and down the James River in a shallop, or small boat. You had been directed by the Virginia Company of London to find "the true, most wholesome and fertile place" to settle. Finally, you pick the site of Jamestown because it appears defensible, has a deep harbor close to shore, and is covered with walnut, beech, oak, and hickory trees. On May 13, 1607, you are one of the 104 weary men to step off the cramped quarters of the three ships onto the swampy lowland. Fear of a massive attack by the Powhatan Indians makes the immediate construction of James Fort more important than building structures for housing. Soon, a triangular wooden wall, or palisade, is built to protect you and the other settlers against future attacks. By the end of June, when Captain Newport returns to England for new supplies, your settlement seems to be well established.

Suddenly, conditions in Jamestown change. Supplies begin to run low and food is spoiling. The weather is turning hot and conditions are very dry. Little or no rain has fallen in weeks, no wells have been dug, and you are forced to drink water from the swamps or river. This water not only carries diseases but is brackish water, containing about 5 times the normal salt one should consume. As conditions worsen, men are dying daily. By autumn, disease reduces the number of survivors to fewer than 60.

Imagine that you are one of the survivors. You must make some hard decisions in order to survive. As with survival of all living things, you must have food, shelter, and water.

You are challenged to choose items that will help you survive. On the next page, you will find a list of 15 items that may have been used in Jamestown during this time. Some of the artifacts have been found in recent archaeological digs.

Rank these items from 1 to 15 according to their importance to you and the other settlers. Place the number 1 by the most important item and continue numbering to 15, the least important. Beside each choice, explain why you gave each item the rank it received and how you plan to use the item to help you survive.

Once you've made your own choices, work with your team of settlers to come to consensus. It is a desperate time and everyone living in Jamestown must agree, not only about the value of these items but about how to use them, as well.

How would you rank these items to survive in Jamestown in 1607?

Place the number 1 by the most important item and continue numbering to 15 to indicate the least important item. Beside each item, write your reasons for giving the item its ranking and explain how you plan to use the item to help you survive. Some of the images are photographs of artifacts found during archaeological digs at Historic Jamestown. (Artifact images courtesy of Colonial National Historic Park.)

Items that may help you survive in Jamestown

Flint and striker
a hard gray stone (flint) and a small piece of steel (striker)
Rank:_____Reason:_____
_____

Salted pork and hard tack
meat preserved by salting and biscuits baked until all moisture is removed

Rank:_____Reason:_____
_____

Candlestick holder
a nonflammable base for candles
Rank:_____Reason:_____
_____

Musket
a common gun of the time
Rank:_____**Reason:**_____
_____

Sword
a weapon with a long metal blade
Rank:_____**Reason:**_____
_____

Ax
a tool with a handle and a heavy sharp blade
Rank:_____**Reason:**_____
_____

Bleeding bowl
a common medical item
Rank:_____**Reason:**_____
_____

Beads
glass trinkets or jewelry
Rank:_____Reason:_____
_____

Coins
English money
Rank:_____Reason:_____
_____

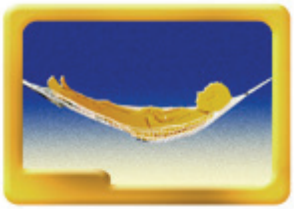
15 meters (about 50 feet) of hemp rope
rope made of natural fiber
Rank:_____Reason:_____
_____

Astrolabe
a tool to measure the altitude of the Sun
Rank:_____Reason:_____
_____

Magnetic compass
a tool that uses a magnetic field to determine direction
Rank:_____**Reason:**_____
_____

Bartman jar
a pottery jar commonly used in the 17th century
Rank:_____**Reason:**_____
_____

Case bottle
a dark-green, square, glass bottle
Rank:_____**Reason:**_____
_____



Hammock
a swinging couch or bed, usually made of netting or canvas
Rank:_____**Reason:**_____
_____

Survival in Jamestown Ranking Answer Key Student Handout

Two Colonial Historical National Park historians separately ranked the same items and explained their reasons for their rankings. Bill Warder was the first expert. Bill is an interpretive ranger for the National Park Service. He interprets historical records to develop educational materials and is known for his expertise. The second expert was Curt Gaul, site supervisor for the Colonial National Historical Park at Historic Jamestowne. Curt also develops historical educational materials and works closely with archaeologists at the Jamestown excavation site.

Both experts agreed that the Jamestown settlers would need to depend upon each other to make difficult decisions. These settlers faced living and working in an unfamiliar climate and environment. Times were stressful, as relationships with the Virginia Indians would swing from peaceful coexistence to outright hostility. What at first seemed like a perfect site to settle actually had sandy soil and little freshwater, making it a poor site for planting. The Jamestown settlers would need to develop a clear understanding of the environment and available materials to survive.

The rankings and explanations below indicate how each expert ranked the items to help them survive in Jamestown.

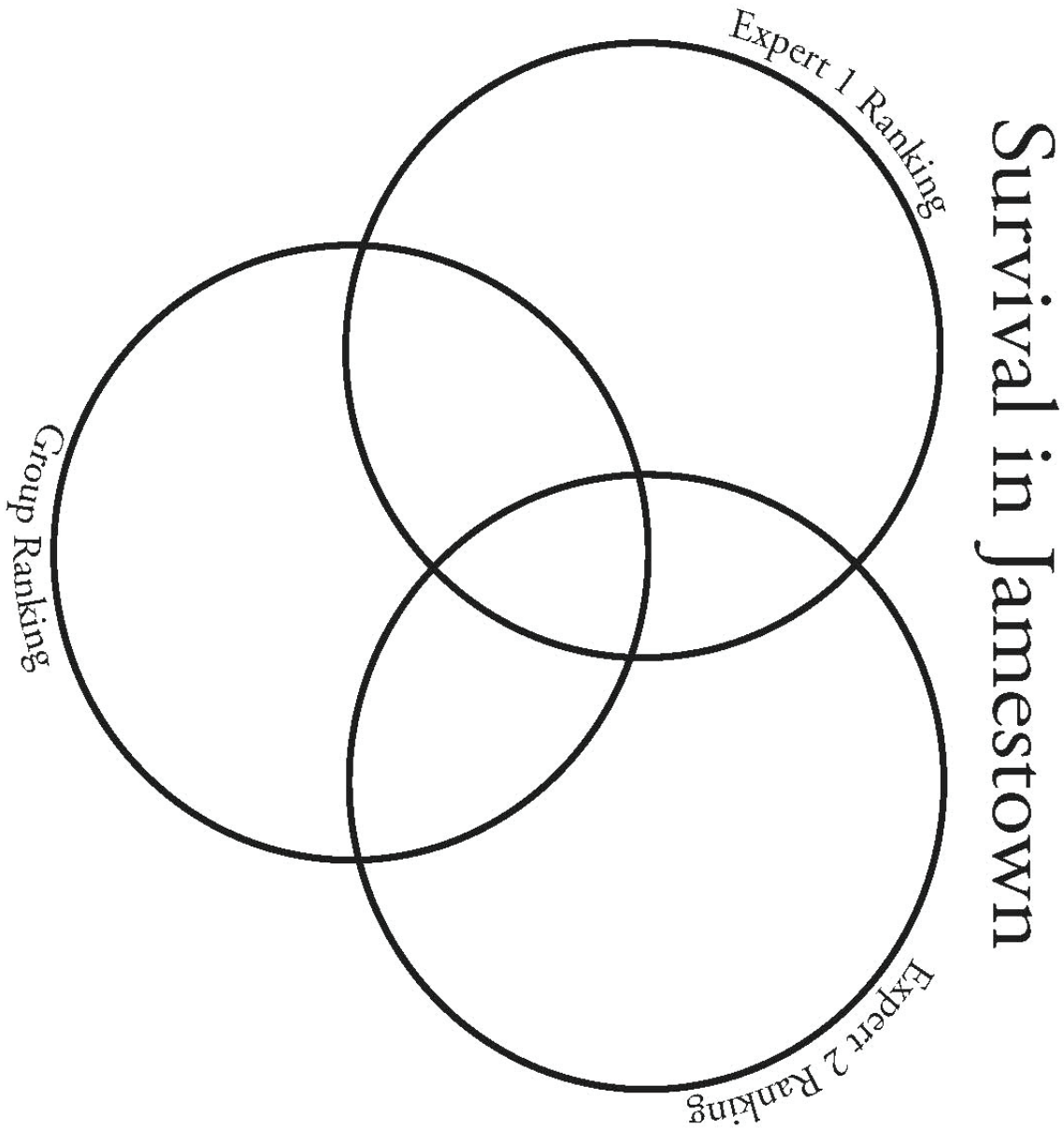
First Expert's Ranking and Reasons	Second Expert's Ranking and Reasons
1) Salted pork and hard tack *"One of the few ways the English had to preserve precious food supplies was by adding salt (salted pork) and baking biscuits until all moisture was eliminated (hard tack). Salted pork and hard tack were preserved to last a very long time. These supplies might be all the food the settlers had to eat until John Smith returned from the trips where he attempted to trade for food with the Powhatans."*	1) Salted pork and hard tack *"Food supplies were needed by the settlers until they were able to find food locally. Salted pork and hard tack lasted longer than fresh meat or fish. The hard tack was soaked in water before it was eaten."*

First Expert's Ranking and Reasons	Second Expert's Ranking and Reasons
2) Musket *"If a deer wandered near the fort, a musket could be used to shoot it, providing meat to feed the settlers. A musket could also be used for protection. Contact with the Powhatans was often unpredictable. Sometime meetings were friendly. Sometimes they were not."* 3) Magnetic compass *"John Smith carried a compass. His compass proved valuable in helping to navigate the James River, which runs basically east to west. John Smith conducted trading ventures on the James River in the fall of 1607 trying to get food from the Powhatans for the hungry settlers at the fort. The compass prevented him from getting lost in unfamiliar areas."* 4) Bleeding bowl *"Many of the settlers at the fort were sick and needed medical care to keep them alive until help arrived or John Smith returned with food."* 5) Beads *"Prior contact with the Virginia Indians had revealed how much the native inhabitants prized beads, both economically and spiritually. Glass beads and coins proved to be some of the most important trade items the English had when they attempted to trade with the Powhatans for food. Beads were a form of money for the Powhatans. They were also important in their religious ceremonies."*	2) Flint and striker *"Fire was needed to cook and provide warmth. Fire was also used to keep wild animals away at night. The flint was sharp and could be used as a cutting utensil, knife, or as a sharpening tool for stakes or lances."* 3) Musket *"Guns were needed to hunt for food and to defend the settlement. Muskets were limited by the supply of powder and shot, and they were not useful in poor weather."* 4) Sword *"Swords were used as axes or machetes. If broken, swords were polished and used as knives."* 5) Ax *"An ax was needed to build houses for shelter and construct the fort. It was also used as a high-priced trade item."* 6) Beads *"Beads were used to trade with the Powhatans in exchange for food."*

First Expert's Ranking and Reasons	Second Expert's Ranking and Reasons
6) Flint and striker *"The need of fire for warmth and cooking has been around for a very long time. As nights grew colder, fire became important for warmth. The settlers needed to cook what little food they had. Fire was also a source of light. The flint and striker were the 17th-century version of matches."* 7) Ax *"An ax was used to cut lumber and wood posts. The settlers also needed firewood and a way to repair the fort walls."* 8) Bartman jar *"Bartman jars were pottery jars used for the storage of liquids. Clean water was scarce, and if it rained, or someone in the fort found a freshwater spring, containers were needed to store the precious water."* 9) Sword *"A sword is an alternate weapon to a musket. Occasionally, muskets would not work properly, especially if the gunpowder became damp."* 10) Case bottle *"Case bottles were square-shaped glass bottles stored in wooden crates to prevent breaking, especially while onboard a ship. The bottles usually held medicine or alcoholic beverages. Because water was so scarce, case bottles were used to store freshwater. The medicine contained in some of the bottles was useful in treating any wounds or illnesses."* 11) Candlestick holder *"The light from a candle held in the candlestick holder provided some emotional comfort from the terrifying dark of a strange new land."*	7) Bleeding bowl *"Medical items such as this were needed to treat settlers who were suffering from ailments. Many settlers would not know what medicines to use and found themselves relying on natural herbs and healing remedies. A bleeding bowl was used to collect blood that was drawn from the body. This common practice was used to rid the body of disease."* 8) 15 meters (about 50 feet) of hemp rope *"Rope was always useful to have on hand. The early structures in the fort were mud-and-stud construction. The saplings used to build these structures were lashed together by rope."* 9) Bartman jar *"The Bartman jar was used to carry liquids, but it was awkward and breakable. The settlers traded the jars to the Powhatans for water jugs made from animal skin."* 10) Case bottle *"The case bottle was delicate and easily broken. It could be used to store drink, in particular, wine. Once broken, the pieces of the bottle could be used as cutting tools."* 11) Magnetic compass *"A compass was important for exploring and mapping Virginia. John Smith talked about showing his compass to the Powhatans who were fascinated by how it worked."*

First Expert's Ranking and Reasons	Second Expert's Ranking and Reasons
12) Coins *"Coins were an alternate trade item. The English found out very quickly that their coins were not going to be used the way they were back in England to buy goods. The Powhatan form of money was often beads and copper. The English learned to shape their coins like elongated beads or to pierce holes in the coins, which were worn as pieces of jewelry. With these modifications, the Powhatans would trade food for the coins."*	12) Candlestick holder *"Candlestick holders and candles were needed to provide light after dark. Candles were made from natural sources, so these were not as necessary as other items."*
13) 15 meters (about 50 feet) of hemp rope *"The rope was used to make traps and snares, but there were many readily available substitutes found in nature, so this item was not essential."*	13) Astrolabe *"Since the Jamestown settlers were no longer traveling on the ocean, the astrolabe was not necessary or practical."*
14) Hammock *"The hungry settlers worried about the uncertainty of the future and did not get much sleep at night. The hammock was not essential for survival."*	14) Coins *"Coins had little value in early Virginia, except as items to trade with the Powhatans for food."*
15) Astrolabe *"The astrolabe was used to navigate by the stars on large bodies of water such as oceans, but was not needed on the James River."*	15) Hammock *"Though a place to sleep was important and a hammock provided a comfortable choice, a tired Jamestown settler would sleep just about anywhere."*

Compare your group's rankings to the experts' rankings. You may consider any item scored plus or minus one number as an agreement. For example: Expert 1 ranked the musket as number 2 and Expert 2 ranked it as number 3. For the Venn Diagram, the musket ranking is an agreement. If your group ranked the musket as a 1, 2, 3, or 4, the item should be placed in the center section where all three circles intersect. If one of your group's rankings matched only with Expert 1's ranking, that item would be placed in the space where Expert 1's circle overlaps with the Group Ranking circle. If an item is not a match for any one, that item is placed outside the three circles.



The year is 2025 and you are part of a four-member team traveling toward the Moon in the *Orion* spacecraft. *Orion* is a gumdrop-shaped spacecraft designed to carry humans from Earth to the Moon. *Orion* is similar in shape, but larger than the capsules used during the Apollo program. Attached, or docked, to *Orion* is the Lunar Surface Access Module (LSAM), which you will use to land on the Moon.

As your spacecraft enters lunar orbit, you spot the lunar outpost. This outpost has grown, having been built piece by piece during past missions. You are excited to see the outpost. It is located on a crater rim near the lunar south pole, in near-constant sunlight. This location is not far from supplies of water ice that can be found in the cold, permanently shadowed part of the crater.

After transferring into the LSAM and separating from *Orion*, you prepare to descend to the lunar surface. Suddenly, you notice that there is a problem with the thrusters. You land safely, but off course, about 80 kilometers (50 miles) from the lunar outpost. As you look across the charcoal-gray, dusty surface of the Moon, you realize your survival depends on reaching the outpost, finding a way to protect yourself until someone can reach you, or meeting a rescue party somewhere between your landing site and the outpost.

You know the Moon has basically no atmosphere or magnetosphere to protect you from space radiation. The environment is unlike any found on Earth. The regolith, or lunar soil, is a mixture of materials that includes sharp, glassy particles. The gravity field on the Moon is only one-sixth as strong as Earth's. More than 80 percent of the Moon is made up of heavily cratered highlands. Temperatures vary widely on the Moon. It can be as cold as -193°C (-315°F) at night at its poles and as hot as 111°C (232°F) during the day at its equator.

Survival will depend on your mode of transportation and ability to navigate. Your basic needs for food, shelter, water, and air must be considered.

You are challenged to choose items that will help you survive. On the next page, you will find a list of 15 items available to you. Rank these items from 1 to 15 according to their importance to you and your crew. Place the number 1 by the most important item and continue ranking the items to number 15, the least important. Beside each choice, explain why you gave each item the rank it received and how you plan to use the item to help you survive.

Once you have made your own choices, work with your team to come to a consensus. Your survival depends on your ability to work with other team members to determine not only the value of these items, but how to use them as well.

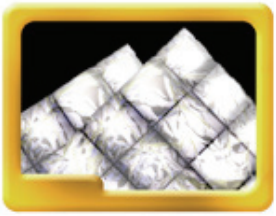
How would you rank these items to survive on the Moon in 2025?

Place the number 1 by the most important item and continue numbering to 15 to indicate the least important item. Beside each item, write your reasons for giving the item its ranking and explain how you plan to use the item to help you survive.

Items that may help you survive on the Moon

Life raft
a self-inflatable floatation device
Rank:_____
Reason:_____
_____

Two 45.5-kilogram (100-pound) tanks of oxygen
pressurized tanks of oxygen
Rank:_____
Reason:_____
_____



Space blanket
a thin sheet of plastic material that is coated with a metallic reflecting layer
Rank:_____
Reason:_____
_____

Lights with solar-powered rechargeable batteries
portable lights powered by solar batteries

Rank:_____

Reason:_____

_____

Signal mirror
a handheld mirror

Rank:_____

Reason:_____

_____

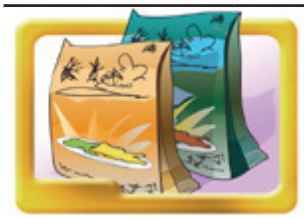
38 liters (10 gallons) of water
a container of water

Rank:_____

Reason:_____

_____

First aid kit
a basic first aid kit with pain medication and medicine for infection
Rank:_____
Reason:_____
_____



Food concentrate
dehydrated food to which water is added

Rank:_____

Reason:_____
_____

Magnetic compass
a tool that uses a magnetic field to determine direction

Rank:_____

Reason:_____
_____

Solar-powered radio receiver-transmitter
a communication tool powered by the sun

Rank:_____

Reason:_____
_____

Map of the Moon's surface
a map showing the Moon's terrain

Rank:_____

Reason:_____
_____

15 meters (about 50 feet) of nylon rope
manufactured rope

Rank:_____

Reason:_____
_____

Parachute
a large piece of silk cloth

Rank:_____

Reason:_____
_____

Space suit repair kit
materials to repair tiny holes in fabric

Rank:_____

Reason:_____
_____

Box of matches
wooden sticks with sulfur-treated heads

Rank:_____

Reason:_____
_____

Two NASA scientists separately ranked the same items and explained their reasons for their rankings. Dr. Carlton Allen was the first expert. Dr. Allen is the curator and manager of the Astromaterials Research and Exploration Science (ARES) Astromaterials Acquisition and Curation Office. This office is responsible for protecting, preserving, and distributing extraterrestrial samples to help others learn more about solar system exploration. These samples include the Apollo Moon rocks and regoliths, Antarctic meteorites, and particles of solar wind. Dr. Allen's background is in planetary science. The second expert was John Gruener. He is a flight systems engineer at NASA's Johnson Space Center and his background is in aerospace engineering and physical sciences with an emphasis in planetary geology. He has worked as a rocket scientist designing missions to the Moon and Mars, as a space farmer growing plants in advanced life-support systems, and as a planetary scientist studying the rocks and soils on Mars.

Both experts agreed that the type of lander in which you were traveling would determine your course of action if you landed on the wrong place on the Moon. If you were in a two-stage lander (one stage for descent and one stage for ascent, like the Apollo lunar module), they suggested that you terminate the surface mission, head back to orbit, rendezvous with *Orion* in lunar orbit, and head home.

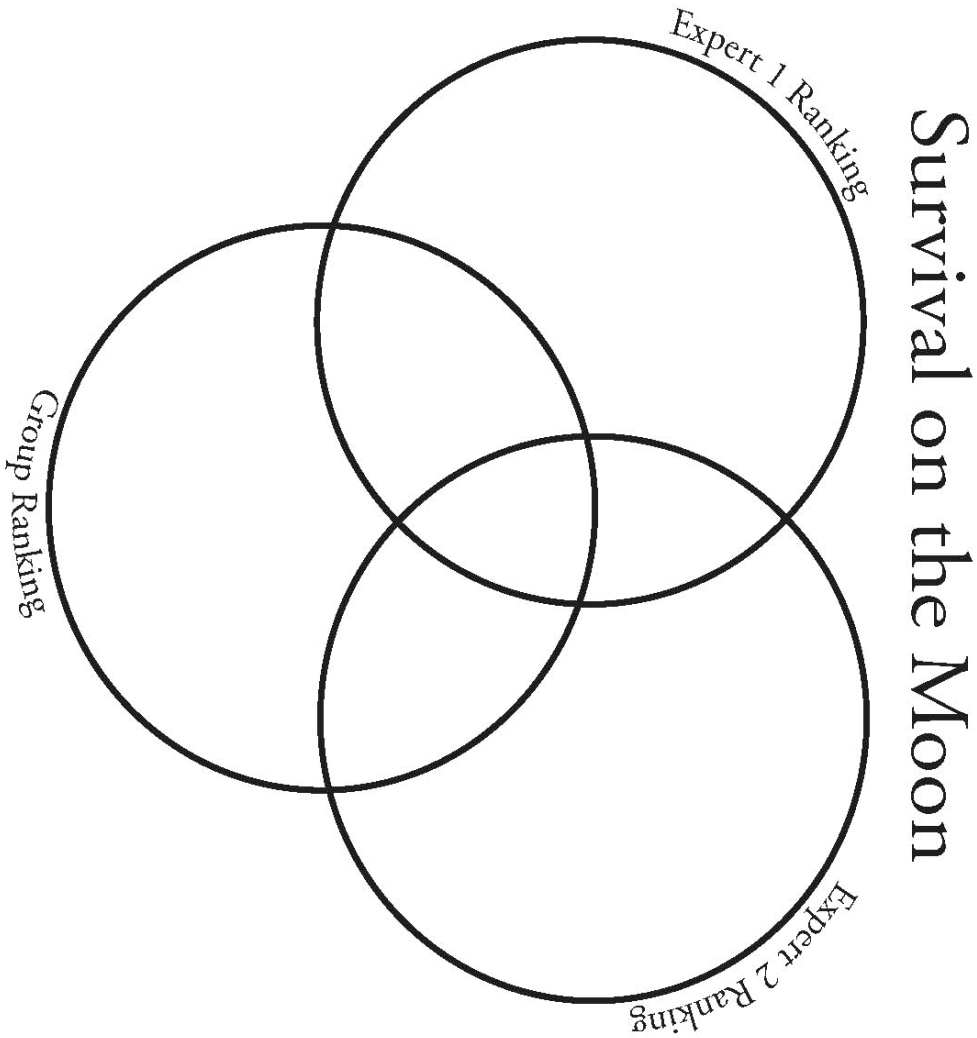
If returning home was not a choice and you were stuck on the Moon, the experts suggested that you sit tight and wait for someone at the outpost to come and get you. They agreed that the safest thing to do in this situation, as in most emergencies, is to stay put and call for help.

If someone from the outpost cannot reach you, then the experts felt that you had no option other than to try to make it to the outpost. The rankings and explanations below indicate how each expert ranked the items to help you reach the outpost.

First Expert's Ranking and Reasons	Second Expert's Ranking and Reasons
1) Two 45.5-kilogram (100-pound tanks of oxygen *"With basically no atmosphere on the Moon, oxygen (O_2) to breathe is the most pressing survival need. The average person needs about 0.84 kilograms (a little less than 2 pounds) of O_2 per day."*	1) Two 45.5-kilogram (100-pound) tanks of oxygen *"Oxygen to breathe is the most important survival need, since the Moon has virtually no atmosphere."*

First Expert's Ranking and Reasons	Second Expert's Ranking and Reasons
2) 38 liters (10 gallons) of water *"Though we believe there is some water in the form of ice on the Moon, there is no liquid water. Water is essential to all life. Currently, each astronaut aboard the International Space Station (ISS) uses about 11 liters (3 gallons) of water daily."*	2) 38 liters (10 gallons) of water *"Water is another basic survival need for the astronauts. Because there is no liquid water on the Moon, the astronauts will need the water they brought with them to survive."*
3) Food concentrate *"Food concentrate is a good source of food and an efficient way to carry it."*	3) Food concentrate *"Although the food concentrate must have water added to be useful, it is lightweight and easy to carry, meeting a third basic need for survival."*
4) Solar-powered radio receiver-transmitter *"Hopefully people from the lunar outpost are looking for you while you are trying to reach them. A solar-powered radio receiver-transmitter is important to maintain this communication."*	4) Solar-powered radio receiver-transmitter *"As people from the lunar outpost are looking for you, you should try to reach them. Maintaining communication with your outpost is essential."*
5) First aid kit *"No matter where you are, a first aid kit is a good idea. Be sure you carry pain medication and medicine for infections."*	5) First aid kit *"A first aid kit takes up little space and may be important to have in case of illness or injury."*
6) Map of the Moon's surface *"A map of the Moon's surface is your primary way to identify your location and to help you navigate."*	6) Map of the Moon's surface *"With no other directional tools available, a map of the Moon's surface is the most important means of finding your way from one location to another."*

First Expert's Ranking and Reasons	Second Expert's Ranking and Reasons
7) Space suit repair kit *"You cannot afford to have any tears in your space suit. Your suit protects you from harsh conditions while you make your way to the lunar outpost. The soil of the Moon (regolith) 'sticks' to space suits and equipment. It is very sharp, like tiny fragments of glass or coral, and can cut holes that put your life at risk."*	7) Space suit repair kit *"Your space suit protects you from the harsh conditions on the Moon. The sharp soil of the Moon can cut tiny holes in the suit, which may compromise its effectiveness."*
8) 15 meters (about 50 feet) of nylon rope *"The nylon rope is useful in scaling cliffs or craters you may have to cross. To prevent injury or in case you cannot walk, rope is helpful for tying you to others."*	8) Life raft *"The life raft makes a great sled for carrying the oxygen and water."*
9) Space blanket *"The space blanket helps reduce heat loss from a person's body. The reflective material reflects about 80 percent of the wearer's body heat back to the body. The reflected side is also used to prevent absorption of sunlight."*	9) Space blanket *"The space blanket is used to insulate the oxygen and water from the hot daytime temperatures. Temperatures vary widely on the Moon. It can be as cold as -193°C (-315°F) at night at its poles and as hot as 111°C (232°F) during the day at its equator."*
10) Signal mirror *"The signal mirror is an important way to communicate during the daylight. The Moon's daylight is brighter and harsher than Earth's. There is virtually no atmosphere to scatter the light, no clouds to shade it, and no ozone layer to block the sun burning ultraviolet light."*	10) 15 meters (about 50 feet) of nylon rope *"The rope makes dragging the life raft easier or may come in handy when crossing difficult terrain."*

First Expert's Ranking and Reasons	Second Expert's Ranking and Reasons
11) Lights with solar-powered rechargeable batteries *"These lights allow for nighttime travel. The nights on the Moon are brighter than nights on Earth, at least on the side of the Moon that is facing Earth. With its clouds and oceans, Earth reflects more light than the dark Moon rocks. Earthlight on the Moon is much brighter than moonlight on Earth."*	11) Lights with solar-powered rechargeable batteries *"The lights are helpful if you travel across large shadowed areas. Some areas in the polar regions are permanently dark."*
12) Life raft *"A life raft is of little use for survival on the Moon. Although it could be used to drag heavy items, the sharp regolith would quickly puncture the raft."*	12) Signal mirror *"The signal mirror is used as a form of communication if the radio is not working."*
13) Parachute silk *"Compared to other items, this item is of little use."*	13) Parachute silk *"Parachute silk comes in handy as a backup sled to the life raft, or as shade."*
14) Magnetic compass *"The Moon has no global magnetic field, which makes a magnetic compass virtually useless."*	14) Box of matches *"With little oxygen on the Moon, the matches are useless."*
15) Box of matches *"Matches are virtually useless on the Moon because there is little oxygen."*	15) Magnetic compass *"The compass is virtually useless because there is no Moon-wide magnetic field."*

Compare your group's rankings to the expert's rankings. You may consider any item scored plus or minus one number as an agreement. For example: Expert 1 ranked a magnetic compass as number 14 and Expert 2 ranked it as number 15. For the Venn Diagram, the magnetic compass is an agreement. If your group ranked the magnetic compass a 13, 14, or 15, the item should be placed in the center section where all three circles intersect. If one of your group's rankings matched only with Expert 1's ranking, that item would be placed in the space where Expert 1's circle overlaps with the Group Ranking circle. If an item is not a match for any one, that item is placed outside the three circles.