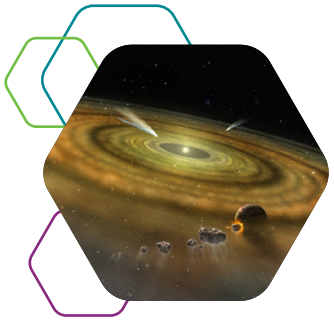


FACILITATOR GUIDE
Observing the Moon

Learning objectives

- From Earth, we can look up and see the Moon with our own eyes.
- We can observe the Moon in even greater detail by using tools, like binoculars, telescopes, and NASA spacecraft.
- We all have personal and cultural connections to the Moon.

Materials

- Spotter scope
- 3 Monoculars
- Tripod
- Red LED flashlight
- White LED flashlight
- Moon ball and stick model and instruction sheet
- Moon observation guide
- Moon graphic showing Apollo landing sites from Exploring the Solar System: Moonquakes activity
- Moon Stories infosheet from Exploring the Solar System: Hide and Seek Moon
- NASA Moon lithographs
- Alcohol swabs or other disinfectant (recommend if participants will use an eyepiece)

If you are using a smartphone in your observing event (optional)

- Smartphone adapter
- Red filter for smartphone

Safety

If you are using any viewing devices during the day, do not use them to look directly at the Sun. Always use a tripod with large viewing devices to keep them stable. Once participant's eyes (or your own) are dark adapted, be aware of the brightness of the Moon through any screen device used for viewing as the sudden brightness can hurt your eyes.

Advance preparation

Before you begin:

- Review all instructions or manuals that come with the spotting scope, monoculars, or whatever viewing device you are using with participants.
- Set up the viewing device in a place accessible to a wide variety of visitors. Viewing devices on short tripods should be placed on a platform or table to bring the eyepiece closer to eye level for the majority of participants. You may also want to have a step stool—we recommend using one with hand support—for younger participants.
- Clear all obstructions in the pathway leading up to the viewing device. In low lighting conditions, use the red LED flashlight to guide participants to the viewing device.
- Spotting scopes, monoculars, and most viewing devices do not require regular cleaning. Occasionally the optics/lens will become smudged or dirty from fingerprints. If this happens the included lens cloth can be used to carefully clean the lens. For further cleaning instructions refer to the viewing device instructions.
- Prepare extra space on a nearby table for the observation guide, red LED flashlight, Moon model, or any other facilitation materials you might use.
- Test any smartphone or big screen attachments that could assist a larger number of participants without adjusting the viewing device's settings.

Please note: *The purpose of the remainder of this guide is to provide facilitators with a quick summary of Moon and general night sky observation tips along with related background content. Look at the annotated link section at the end of the guide to go further with source documents from NASA and the Moon observing community.*

Notes to the presenter

If you are planning a Moon observing event

Most Moon observing events take place in the evening or at night. But there's no reason not to have Moon observing sessions during the day. Holding a daytime event during regular operating hours can make the event more accessible and might be easier for your institution or for some participants. Daytime Moon viewing is especially good during the Northern Hemisphere winter when the Moon is near its first quarter phase—look up in the late afternoon.

For viewing events, determine a date on which the Moon will be high in the sky. Select a time using a source like the one linked here: *www.bit.ly/mooncheck.* The Moon is best viewed when it is a crescent or in the first quarter, when the terrain casts longer shadows and the features become much easier to see. Note the times when the Moon will be visible—and high enough in the sky to see above any trees or buildings that may be around—to plan when you'll need to arrive to set up and when participants should arrive to view it.

Special considerations for younger participants

Using a spotting scope, monoculars, or any viewing device may be a new experience for young children. Allow them time to explore this tool and to delight in the experience before directing their attention to the activity's tasks. Try reminding them of where else they may have seen this tool, and ask them, "What other things might you want to look for with your binoculars? What about when you're outside?" Even those who have tried them in the past may find it difficult to see through them and may need help and guidance. Allow children to build their confidence by using these age-appropriate strategies developed by the *My Sky Tonight* project of the Astronomical Society of the Pacific.

- **Provide Information** about the viewing device as a tool for magnifying distant objects. For example, say, "Monoculars are a tool that helps people see things that they can't see with only their eyes."
- **Demonstrate** how to hold the monocular and try saying things like, "If I want to see the objects on the Moon poster, I'll look through the small lenses and point the binoculars toward the Moon."
- **Ask questions/make statements** that encourage children to describe what they are noticing. For example, "You're looking at the Moon through the monocular, tell me what you see."

Pick the location

Select a safe viewing location. If viewing at night try to choose a location that is not brightly lit. One advantage of viewing the Moon is that it is very visible even with city lights, but a darker site will result in better views of the Moon. Remember that an easily accessible spot may increase the number of people who participate.

Dark-adapting your eyes

When you first step outside on a dark night, you'll notice you can barely see anything. But after about 30 minutes you'll be able to see objects much more clearly. This is because your eyes acclimatise to darkness over time. When viewing the night sky, it is important that your eyes—and those of your participants— adapt to the dark. Using bright white light flashlights to find your way around or look around will keep your eyes from adapting. The solution? Use the red LED flashlight included in the toolkit to illuminate areas you and your participants need to see. Using red light will not disrupt dark adaptation as much as white light. For facilitators using the optional smartphone attachment to the spotter, a reusable red filter has also been included to use on your smartphone screen.

Please note: *If you are observing multiple night sky objects, you might want to recommend participants save a bright Moon for last. This will help extend dark adaptation.*

Questions to use with participants while observing the Moon at night

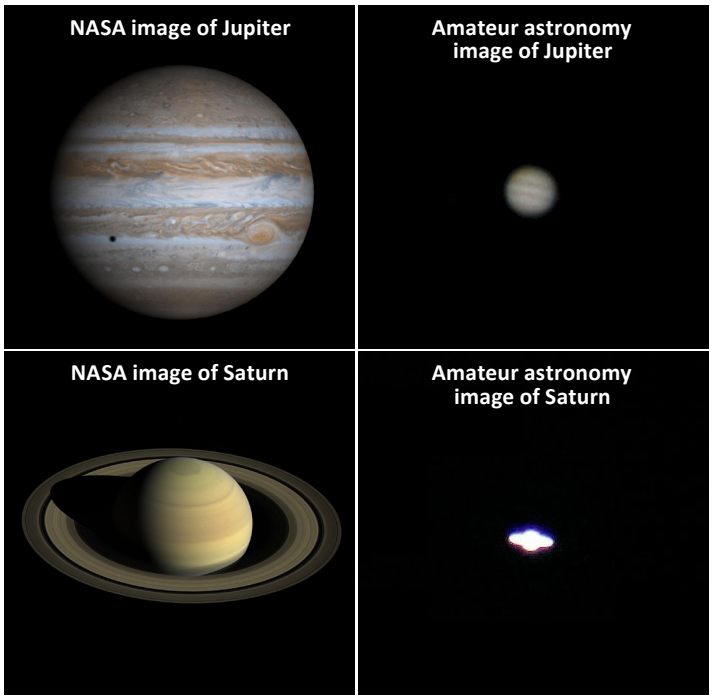
- How much of the Moon can you see tonight? What shapes does it look like to you right now? What other "moon shapes" have you seen before? Do you think the Moon's shape really changes?
- What else can you see? Any strange patterns or features?
- Can you see any craters looking at the Moon with only your eyes? What about using the viewing device? How many can you see?

Tips on Spotting the Moon

To start, place the spotting scope on a level surface and point it towards the Moon. Look along the tube of the spotting scope to align the Moon in the field of view. If the Moon is sufficiently bright and your viewing location is very dark, you might be able to use the spotter shadow. The basic technique is to make the shadow as small as possible to line up the Moon in the spotter. Throughout your observation event, regularly check to make sure that the Moon is visible in the field of view. It will appear to move because of the rotation of the Earth.

Other Easy Objects to Spot in the Night Sky

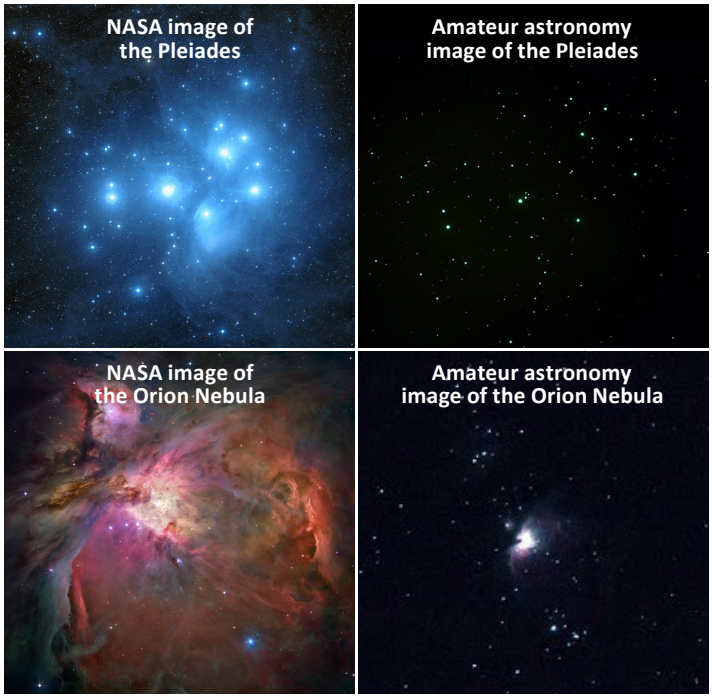
Participants can view many interesting objects in the night sky with low-powered viewing devices—objects that are larger than the single pin-point stars and smaller than the moon. After centuries of conjecture on the nature of these objects, we now know many are planets, nebulas, and star clusters thanks to powerful telescopes on Earth and in space. Creating stories and building on our understanding of these objects continues today. Let's review several objects that will help expand your observing event beyond the Moon.



Comparing NASA and amateur astronomy images: planets. Left column: Jupiter (top) and Saturn (bottom) images from NASA's Cassini mission. Right column: Jupiter (from flickr user mdsharpe) and Saturn (from flickr user justingood) images taken with amateur viewing devices.

Planets can be spotted in the night sky year-round. While they may look like a star to the naked-eye, when seen through a viewing device, the "star" can be clearly seen as a planet with a finite diameter. With the spotter or monoculars, Mars appears as a red circle. Jupiter appears as a grey-white circle and its moons may be viewable as pinpoints of light close to the white circle. Saturn will appear as a white circle with its rings making points off the sides of the circle. Participants who have seen NASA images of the planets may be disappointed in the less detailed view they have of these planets—but seeing space objects live in the night sky offers an immediate connection that is much different from seeing reproduced images.

To check if a planet is visible in the night sky at your location and during your observation event and use the source linked here: *www.bit.ly/planetcheck.*



Comparing NASA and amateur astronomy images: stars and nebulas. Left column: images from NASA's Hubble Space telescope mission of the Pleiades (top) and the Orion Nebula (bottom). Right column: the Pleiades (from flickr user blobrana3) and Orion Nebula (from flickr user zboydmark) images taken with amateur viewing devices.

In addition to planets, Orion Nebula and the Pleiades are visible in the night sky of the northern hemisphere during the winter month. The Pleiades—an unofficial grouping of stars called an *asterism*—appears as many bright stars clustered together, usually seen as 6 or 7 stars. This group of stars is known to many cultures as the seven sisters/daughters/girls or as the six brothers/sons/boys. The Pleiades is within the constellation Taurus. With a more powerful telescope, many fainter stars can be seen. NASA Scientists have used the Hubble telescope to obtain scientific data of the Pleiades, discovering too many stars to count. Most cultures on Earth have a story associated with this constellation. It is called by many different names, for example Subaru in Japan, Cat iheḍ by the Tuareg Berbers of the northern Sahara in Africa, and hundreds more unique names by Pacific Islanders, Native Alaskans, and Native Americans in the Indigenous Nations within the United States. The Orion Nebula appears as a fuzzy star-like object in the 3 "stars" in a row that make up the sword hanging down from Orion's belt, also 3 stars in a row. NASA scientists have evidence that this nebula is a star-forming area with an abundance of hydrogen, oxygen, and sulfur elements.

To see a list of visible night sky objects throughout the year download these Universe Discovery Guides from NASA's Night Sky Network. Follow the links to the corresponding month of your observation event.
https://nightsky.jpl.nasa.gov/news-display.cfm?News_ID=611

You can also find constellations in the night sky using this easy-to-make star wheel for the Northern Hemisphere from the Lawrence Hall of Science at University of California, Berkeley.
https://www.lawrencehallofscience.org/do_science_now/science_apps_and_activities/star_wheels

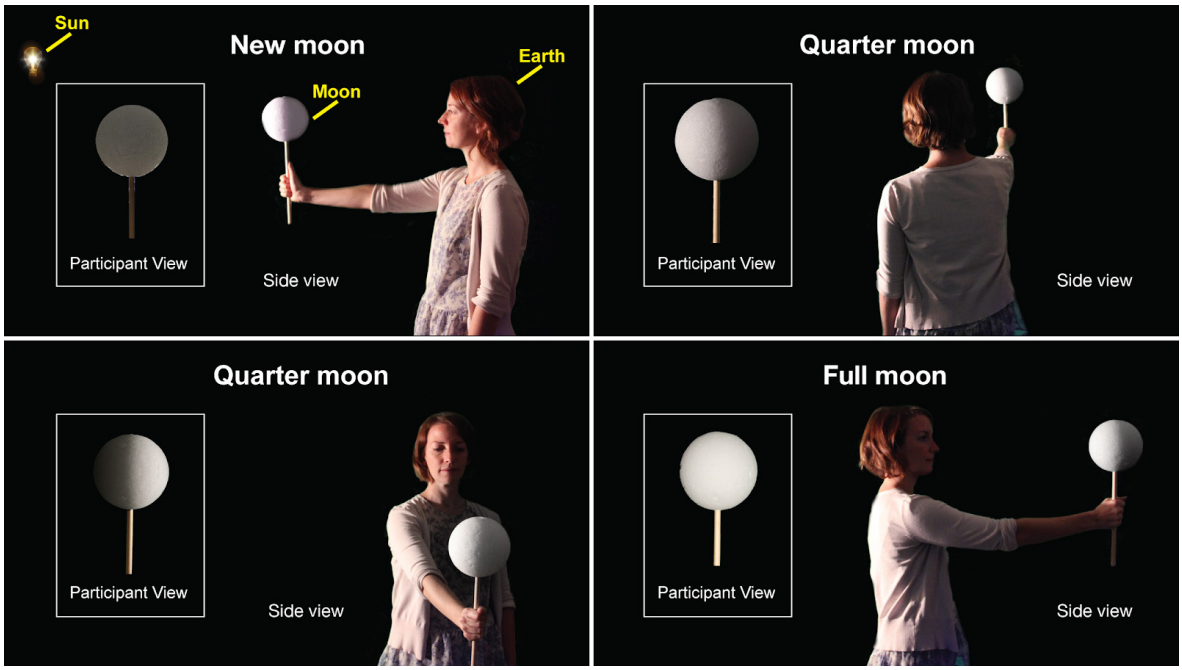
Moon Difficult Concepts

With a common word like “moonlight”, and preconceptions on how all objects in the night sky emit light similar to stars, some participants may struggle to understand the source of light we see from the Moon. The Moon does not generate its own light—it shines because it reflects the Sun’s light. The Moon is much closer to us than the Sun or other planets, so it is the brightest object in our night sky when it is visible. If the Moon is visible during the day, it is often the only other sky object visible besides the Sun.

Except on very rare occasions, half of the Moon’s surface is illuminated by the Sun (just like half of the Earth is lit by the Sun each day.) As the Moon orbits the Earth, it also spins on its axis at the same time. Because it takes the same amount of time for the Moon to spin around on its axis as it does to go around the Earth once, observers on Earth always see the same side of the Moon. We call this side the “near side.” Spacecraft have taken images of the Moon’s “far side.” Many people call this side the “dark side” of the Moon, but both sides actually get sunlight. The half of the Moon that is illuminated by the Sun changes over time, so there is no whole side of the Moon that is dark all of the time.

Participants may also believe the Moon changes shape—however it is always round like a ball. Depending on the relative positions of the Earth, Sun and Moon, an observer on Earth sees different amounts of the illuminated half of the Moon. Sometimes, we see just a small sliver of the illuminated half, while the rest is on the side of the Moon away from Earth. Sometimes, we can see all of the illuminated half and from our point of view the Moon looks “full.”

To assist participants in visualizing this phenomenon, you can pair a simple Moon model, made up of a ball on a stick, with a bright light. Facilitators can use the model in a quick interaction with participants by showing how a flashlight illuminates a portion of the spherical “Moon”—as shown in the photo to the right. This model will work best in a dim or dark space. For a longer interaction, facilitators can act as the “Sun” and hold the flashlight pointed at a participant acting as the “Earth”while facing a “Moon” ball held in their outstretched hand. Without moving the light source, have the participant spin around on their feet to change what portion of the lit up half of the ball they can see. Have them rotate their body to see none, half, or all of the lit up side of the ball from their “Earth” perspective. Facilitators can also ask additional participants surrounding the model, who are free to move around the ball, to confirm the lit up half of the ball is not changing shape. The photo series below show the relative positions of the light source, ball, and the “Earth” participant to reproduce the corresponding new, quarter, and full phases of the Moon.



Moon phases demonstration: These four panels show relative positions of the light source, Moon ball, and participant to demonstrate some phases of the Moon. The light source is always to the left in arrangements. The participant view insets represent the view from an observer on Earth. Clockwise from the top left: during a New moon the lit up side of the Moon is not visible from Earth; for a Quarter moon, half of the lit up side of the Moon is visible from Earth; and for a Full moon, all of the lit up side of the Moon is visible from Earth.

Please note: In order to see all of the lit up side of the "Moon" in this model—especially during the "Full Moon"—the ball might have to be above the participant's head or the facilitator may need to raise the light.

For the full Moon phases activity please visit:
https://www.jpl.nasa.gov/edu/teach/activity/moon-phases/

Moon Background Information

This list of frequently asked questions—and answers—may assist you in your Moon observing activities. Remember, it is always appropriate to inform participants that you don't have the answers to all questions and to encourage them to explore more on their own.

How big is the Moon?
The Moon is about 3,500 kilometers (2,160 miles) in diameter. This is close to the distance from New York City to Phoenix, Arizona.

How far away is the Moon?
The Moon is roughly 380,000 kilometers (240,000 miles) from Earth.

How old is the Moon?
The Moon is about 4.5 billion years old. Scientists know this by dating lunar rock samples retrieved by NASA's Apollo missions.

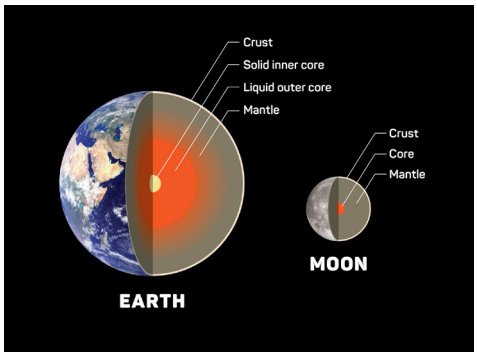
How did the Moon form?
The leading hypothesis is that the Moon formed after a giant asteroid—about half the size of Earth—crashed into our planet roughly 4.5 billion years ago. That giant impact launched debris into orbit around Earth. Eventually these rocky bits clumped together, forming the Moon. Scientists still have many questions and are learning more about how the Moon formed.

What are the bright and dark areas on the Moon?
The lighter areas, called the Lunar Highlands, are made up of a white-ish anorthosite rock and are the oldest and most cratered parts of the Moon. They formed when the Moon was young and so hot that part of it melted, forming an ocean of magma across the Moon's surface. Over time, this magma cooled and solidified.

The darker areas are impact basins formed when really big asteroids hit the Moon. Over time, magma from deep inside the Moon made its way to the surface, flowed into these basins, and cooled into a kind of rock called basalt. These areas are called Maria ("MAHR-ee-ah") or Mare (singular) which is Latin for "seas," because that's what these areas looked like to early astronomers. They're physically different kinds of rock: white-ish anorthosite, and dark basalt.

Why does the Moon have so many more impact craters than the Earth?
Most asteroids or comets that enter Earth's atmosphere actually burn up (shooting stars), so there are many fewer impact craters to begin with. Earth's surface is about 70% water. Many of Earth's craters are actually on the ocean floor. The Earth's surface is constantly being eroded by wind, rain, and glaciers, which means that impact craters that do form get worn away and buried over time. But the Moon doesn't experience much erosion since it lacks any significant atmosphere and flowing water. That's why the Moon has so many more impact craters—they tend to stick around. The footprints left by NASA's Apollo astronauts are still there too!

What's inside the Moon?
Beneath the Moon's outermost layer ("crust"), scientists believe there's a layer called the mantle. This part of the Moon is composed of rock, and some parts of it are probably hot enough to flow. Deeper inside, the Moon likely contains a metallic core made of iron. Scientists believe that the Moon has an inner core that is relatively small compared with the Earth's. The Moon, and other rocky planets and moons, have an internal structure with layers because at some point early in their formation they melted or partially melted. The heavy materials – like iron– sank to the center, and the lighter materials—like rock—floated to the surface. The crust of the Moon is made of the lightest (least dense) materials.



What is the name of the boundary between the portion of the Moon that's illuminated and the portion that's not?
The Moon's face is divided into a sunlit side and a shadowed side. The imaginary line dividing these two regions is called the terminator. The terminator is a great place to look for things like craters and mountains since features along the terminator cast long shadows and therefore stand out.

What is it like to walk on the Moon?
Because the Moon is less massive and smaller than the Earth, you'd feel significantly lighter on the Moon. (In fact, you'd weigh only about 1/6th of what you weigh on Earth.) So walking would be easier, and you could jump higher and lift things that were too heavy for you on Earth. Of course, you'd need a spacesuit that would allow you to breathe, drink, and maintain your body temperature. It's very hot (up to 253 F, 123 C) on the daytime side of the Moon but very, very cold on the nighttime side.

Annotated Link Section

NASA Science Earth's Moon
Moon interactive to explore landing sites, under the surface, and recent lunar data.
https://moon.nasa.gov/

International Observe the Moon Night Guide
Full guide with related activities & games, worksheets, Moon maps, and much more.
https://moon.nasa.gov/resources/367/international-observe-the-moon-night-guide

Skywatcher's Guide to the Moon [Handout] from the Astronomical Society of the Pacific
Alternative Moon observation guide for participants that includes named surface features.
https://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=331

Spotting Craters [Activity] from the Astronomical Society of the Pacific
A demo that shows why the features you can see in most detail are those along the terminator.
https://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=388

NASA Moon Mission Lithographs or Fact Sheets
A selection of NASA lithographs about the Moon ranging from Apollo history to current lunar data.
https://lunar.gsfc.nasa.gov/lithographs.html

Moon Landing Sites
Graphic showing where humans have landed on the Moon and collected samples.
https://moon.nasa.gov/resources/65/moon-landing-sites/

Staff training resources

Refer to the *Tips for Leading Hands-on Activities* sheet in your activity materials.

- Content Training Video: https://vimeo.com/441410265
- Edu-Cathalon Facilitation Training Video: https://vimeo.com/304241578

The NISE Network has a curated list of programs, media, and professional development resources that directly relate to the toolkit. These resources can be viewed and downloaded from: *www.nisenet.org/earthspacekitextensions*

Credits and rights

This guide was adapted from International Observe the Moon Night Guide, developed by NASA. Retrieved from: *moon.nasa.gov*

Phases of the Moon model image series courtesy of NASA JPL.

Moon and Tycho crater images courtesy NASA.

Internal structure of the Earth and Moon image and ball and stick model photo, Emily Maletz Graphic Design for the NISE Network.

NASA's Cassini image of Jupiter courtesy of NASA/JPL/University of Arizona.

NASA's Cassini image of Saturn courtesy of NASA/JPL-Caltech/Space Science Institute.

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NASA Hubble Space Telescope image of the Pleiades courtesy of Davide De Martin & the ESA/ESO/NASA Photoshop FITS Liberator.

NASA Hubble Space Telescope image of Orion Nebula courtesy M. Robberto (Space Telescope Science Institute/ESA), NASA, and the Hubble Space Telescope Orion Treasury Project Team.

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Developed and distributed by the National Informal STEM Education Network.

This material is based on work supported by NASA under cooperative agreement award number NNX16AC67A and 80NSSC18M0061. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the view of the National Aeronautics and Space Administration (NASA).