HIDDEN NO MORE

Facilitation Guide

MOREHEAD PLANETARIUM+ SCIENCE CENTER

Hidden No More
Facilitation Guide

Introduction

Grant Information

This exhibit is the first phase of a three-phase project connected to the NSF grant #1906686 Hidden No More: Shedding Light on Science Stories in the Shadows. More information about the grant can be found at https://moreheadplanetarium.org/program/special-initiatives-programs/hidden-no-more/

Light and Color

Phase 1 of the *Hidden No More* exhibit focuses on the science of color and how this aspect of light can be used for scientific discovery. The exhibit engages visitors in learning about the lives and work of Kamāl al-Dīn al-Fārisī, who experimented with rainbows in the 14th century, and Mercedes López-Morales, who searches for Earth-like exoplanets in the 21st century. Visitors learn how the colors of the rainbow connect the stories of these two scientists across centuries.

We Need Your Feedback

One of the goals of the grant is to improve upon each proceeding phase. We plan to do this with formal evaluation, but we would also like to hear any informal feedback from your institution's staff. Feedback can be sent to: Michele Kloda (mkloda@ad.unc.edu)

Exhibit Components

Hands-On Interactives

Scientist Videos

Virtual Reality Experiences

Studying Spectra

Help visitors discover exoplanets that can support life

This activity focuses on two related questions that Mercedes López-Morales must answer when she is studying a planet that has been discovered outside our solar system. What is this exoplanet made of? And can this planet support life?

Visitors learn that the science of color—and the visible light spectrum, in particular—help Dr. López-Morales find out about the atmospheric compositions of exoplanets.

MAIN IDEA

Visitors solve a spectroscopy puzzle to identify molecules in an exoplanet's atmosphere and determine if the exoplanet is habitable (suitable for life as we know it).

EXHIBIT COMPONENTS

- Activity information panel
- Acrylic puzzle pieces representing atmospheres of three exoplanets

EXHIBIT COMPONENTS, continued

- Acrylic puzzle pieces representing absorption lines of three molecules: methane (CH_4), oxygen (O_2), and water (H_20)

Note: The puzzle pieces show simplified versions of data gathered by telescopes like the Hubble Space Telescope and James Webb Space Telescope—telescopes that Dr. López-Morales uses in her work.

TRY THE ACTIVITY

1. Choose an exoplanet absorption spectrum to analyze.
2. Place each molecule piece on top of the exoplanet's absorption spectrum to match the missing wavelength lines and discover what the exoplanet is made of.
3. Based on your analysis, does the exoplanet have oxygen, water, or methane? These substances can support life.
4. Analyze the other exoplanets to choose the exoplanet that would be the best candidate for further study by Dr. López-Morales.

GUIDING QUESTIONS

- What does a planet need to support life as we know it? Do you see any of those substances in the atmospheres of these exoplanets?

MAKE CONNECTIONS

TO OTHER EXHIBIT RESOURCES ABOUT DR. LÓPEZ-MORALES

- **The documentary film introduces visitors to Mercedes López-Morales and her work. She shares her journey from her home in the Canary Islands to her search for habitable exoplanets.**
- **A virtual reality experience immerses visitors in Dr. López-Morales's search for exoplanets. The visitor travels in outer space to gather data through absorption spectroscopy. The same three molecules being searched for in the VR experience are also the focus of the "Studying Spectra" hands-on, tabletop experience.**
- **Dr. López-Morales is included in the "Sorting Scientists" game.**

GUIDING QUESTIONS, continued

- Of the things you think might be helpful, do any of these exoplanets have them? How can you find out?
- Are there substances that we might not want to have a lot of in a planet's atmosphere?
- Have you ever wondered if Earth is the only planet where humans can live? Would you like to live on another planet—or maybe just visit?
- Would you like to do research like Dr. López-Morales and find out if there is another habitable planet in the universe?

ABOUT THE SCIENCE

Scientists like Dr. López-Morales can use absorption spectroscopy to determine what an exoplanet is likely to be made of.

Black absorption lines appear on the spectrum (below) when elements and molecules absorb those wavelengths of light. The positions of those lines along the spectrum reveal which elements and molecules are present.

Dr. López-Morales analyzes the spectrum of sunlight (light from the planet's star) filtered through an exoplanet's atmosphere. By observing which wavelengths of light have been absorbed by the atmosphere—and are therefore missing from the absorption spectrum—Dr. López-Morales can determine which potentially life-supporting substances may be present on the planet.

FACILITATION TIPS

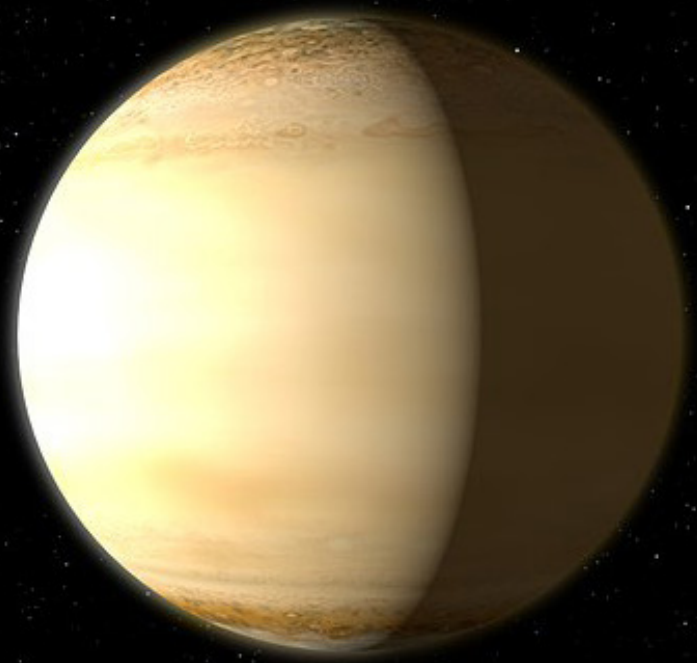
- Absorption spectroscopy is a concept that visitors may not have learned about before. You can assist them by posing guiding questions. You can also reinforce the diagram on the activity information panel, which explains how a star's light is filtered through a planet's atmosphere to reveal substances that are present on the planet.
- Connecting this activity to Dr. López-Morales's research will provide a real-world context for the activity, helping visitors consider how the things they are learning about today can be useful.
- Before facilitating this activity, experiment with it yourself. This can help you anticipate visitors' questions and discuss their ideas about the ability of the three exoplanets to support life.

INNOVATE ON THE ACTIVITY

Include images and information from recent discoveries about exoplanets at the "Study Spectra" station and in facilitation.

The James Webb Space Telescope, launched on December 25, 2021, is one source of exciting news about exoplanets and what they are made of. And Dr. López-Morales is making news, too!

In 2022, Dr. López-Morales was part of a group of scientists who used JWST to see carbon dioxide (CO_2) on a planet outside our solar system for first time. The planet—named WASP-39b—is a gas giant orbiting a star 700 light-years from Earth.



An artist's impression of WASP-39b and its parent star

Changing Color

Invite visitors to use light to change the colors of objects

For a long time, people thought that colors are present in objects. But Kamāl al-Dīn al-Fārisī observed that objects change color in different kinds of light, like moonlight and firelight. This indicated that light and color are connected.

Scientists have continued to learn about color—how wavelengths of light are reflected and absorbed to make colors that humans can see. But the science of color can still be difficult for people to understand.

Flowers and toys and food and uncountable other objects in our natural and built environments appear to be different colors. This activity explores the role of light in our perceptions of these colors.

MAIN IDEA

Visitors use the *Hidden No More* color-changing box to test Al-Fārisī's observations. They observe that the colors of light affect our perception of the colors of objects.

EXHIBIT COMPONENTS

- Activity information panel
- Color-changing box, which enables visitors to see objects (LEGO bricks) in different colors of light. The color-changing box includes green, red, and blue light sources (the primary colors of light). The box's window also lets in the ambient white light of the exhibit space.

TRY THE ACTIVITY

1. Look through the window of the color-changing box and observe the objects in white light.
2. Press each button to shine a different colored light onto the objects inside the box.
3. Observe what happens to the colors of the objects under different colors of light.

GUIDING QUESTIONS

- When the blue light is on, what colors do the LEGO bricks look like? Red? Green?
- How do the colors of the LEGO bricks change when you change the lights? Try focusing on one brick while changing the lights.
- Under white light, what changes? Find a blue brick in white light and then turn the blue light on. What color is

INNOVATE ON THE ACTIVITY

- **Colorful LEGO bricks are provided with the *Hidden No More* color-changing box. You may wish to add to or exchange these with other vividly colored small objects that will interest your visitors. Your choices can refresh the exhibit and encourage new conversations.**
- **For instance, tangram shapes or toy cars and dinosaurs may be particularly engaging for small children and their families.**
- **A display of various pressed flowers may spark new thoughts about our colorful natural world, which also includes vibrant beetles, vegetables, rainbows, and so much more! Visitors may be inspired to make a special search for favorite or unusual colors in nature.**

MAKE CONNECTIONS

TO OTHER EXHIBIT RESOURCES ABOUT KAMĀL AL-DĪN AL-FĀRISĪ

- **The short animated video included in the *Hidden No More* exhibit explains where and when Kamāl al-Dīn al-Fārisī lived, and how he made his groundbreaking discovery about rainbows.**
- **A virtual reality experience invites visitors into an observatory like the one in which Kamāl al-Dīn al-Fārisī worked. Visitors test al-Fārisī's ideas about how the colors of the rainbow are formed.**
- **Al-Fārisī worked with spheres, so the exhibit kit includes transparent spheres and prisms. Visitors can consider how these different tools interact with light to make colors, turn images upside down, and more.**

GUIDING QUESTIONS, continued

the brick now? Try this with the red and green lights, too!

- Why do you think the bricks are easier to see in white light? Can you see the bricks when no lights are on?
- What happens when you turn on more than one light at a time?

ABOUT THE SCIENCE

Depending on what color they are, objects reflect and absorb different wavelengths of light. As a result, objects look different to us in different colors of light.

For instance, under a white light, a red object absorbs all the colors in the visible spectrum except red. The red object reflects only the red light back to us. Under a blue light, the red object cannot reflect red light—it absorbs the blue light and appears to be black.

FACILITATION TIPS

- This activity tends to need less facilitation and holds visitors' attention longer than the other hands-on activities.
- Before facilitating this activity, experiment with it yourself. This can help you anticipate visitors' questions and recommend ways for them to discover what the color-changing box can do.

Blending Beams

Invite visitors to mix the colors of light to make new colors

More than 300 years before Isaac Newton famously experimented with light and color, Kamāl al-Dīn al-Fārisī had figured out that rainbows are formed when raindrops separate sunlight into different colors. This hands-on activity can help visitors understand how the white light of the Sun combines the colors of the rainbow.

MAIN IDEA

Visitors experiment with the three primary colors of light (red, green, and blue) to make different colors.

EXHIBIT COMPONENTS

- activity information panel
- light mixer that illuminates the three primary colors of light (red, green, and blue)

TRY THE ACTIVITY

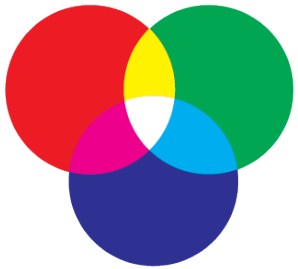
1. Use each knob on the color mixer to turn on a different color of light. You can also use the knobs to make the

colors more or less intense.

2. Mix colors of light at different intensities to make different colors appear.
3. Mix red, green, and blue light to see what happens. (White light should appear.)
4. Try making your favorite color! With just red, green, and blue lights, you can make any color visible to human eyes.

GUIDING QUESTIONS

- What color do you see when only one light is on? Two lights? Try making the lights brighter or dimmer!
- Turn the green light to maximum brightness and then slowly make the red light brighter. What changes?
- When two colors overlap, what do you notice? Try this with the same brightness for both colors or different brightnesses!
- Turn the brightness on all three colors all the way up. What do you see in the middle where all three colors overlap? (They are likely to see white light.)
- Does the color mixer help us see that sunlight (white light) can become all the colors of the rainbow?



INNOVATE ON THE ACTIVITY

- **Experimenting within the exhibit can be a rich source of discovery and learning. Invite visitors to experiment with the filters—layering several filters at a time, using them to look at the "Blending Beams" exhibit, putting them in front of their cameras when they take pictures at the "Photobooth."**
- **Include the latest images from the Hubble Space Telescope or James Webb Space Telescope (available at NASA.gov) to look at under the filters.**
- **Provide paper and crayons or markers so visitors can make their own pictures to view under the filters. They can even reverse the process—holding a filter over their paper as they color, then looking at their picture without the filter!**

PROMPT A DISCUSSION

ABOUT INVENTIONS THAT USE THE SCIENCE OF LIGHT AND COLOR

At the end of the animated film about al-Fārisī included in the *Hidden No More* exhibit, visitors are encouraged to think about new things we know—and can do—because of scientists like al-Fārisī who have helped us understand light and color.

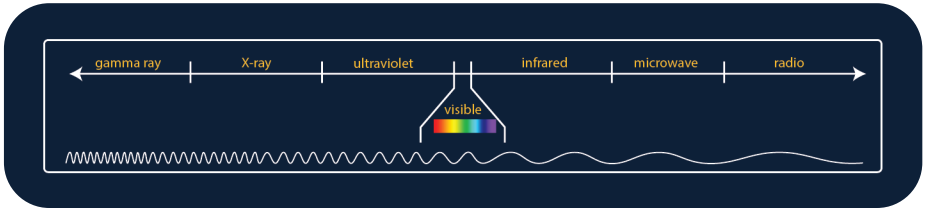
The animation asks, "What new inventions involve light and color?" and mentions the color monitor on which the animation is shown.

Examples of other electronic devices that involve light and color could range from cameras, computer screens, and color TVs to traffic lights, neon signs, and (fictional) light sabers!

ABOUT THE SCIENCE

Most human eyes have receptors that can detect red, green, and blue—the primary colors of light—but they cannot detect other wavelengths on the electromagnetic spectrum (for example, infrared or X-ray).

The wavelengths that humans can see are in the range of visible light on the electromagnetic spectrum (below). Visible light shows us the colors of the rainbow.



White light (like the light we see from the Sun or from a white light bulb) is a mixture of the colors of light that we can see.

FACILITATION TIPS

- Visitors may need pointers on using the color mixer. Mention that the knobs not only switch the lights on—they can turn the lights' intensity up or down to create more colors.
- Before facilitating this activity, experiment with it yourself. This can help you anticipate visitors' questions and recommend ways for them to explore the light mixer's capabilities.

Filtering Color

Engage visitors in using color filters like astronomers

Like the "Changing Color" activity, "Filtering Color" engages visitors in learning how light—and the various conditions of light—affect our perceptions of color.

This topic of light's connections to our perception of colors interested Kamāl al-Dīn al-Fārisī. In our own time, astronomers like Mercedes López-Morales understand that they can filter certain colors of light so they can better understand the images reaching their telescopes from space.

MAIN IDEA

Visitors explore how color filters can change the colors of objects we see—and how they can make some objects appear more or less visible to us.

EXHIBIT COMPONENTS

- activity information panel
- color filters (In addition to filters in the primary colors of light—red, green, and blue—the exhibit kit also includes

EXHIBIT COMPONENTS, continued

orange, yellow, and purple filters.)

- pictures of contrasting, colorful shapes
- pictures of colorful nebulae (A nebula is a cloud of dust and gas out in space. Nebulae can result from dying or dead stars; they can also be signs of emerging new stars.)

TRY THE ACTIVITY

1. Place each color filter over the pictures of shapes and nebulae to see what happens.
2. Notice if any of the filters change the colors in the pictures. Notice if the colors change a little bit or a lot.
3. Notice if some filters make parts of the pictures disappear—or if they make parts of the pictures easier to see.

GUIDING QUESTIONS

- When you look at the images without any filters, what colors do you see? Do any stand out?
- Try looking through a filter! Do the colors in the pictures change? How?
- When you use the red filter, do you see more red on the pictures or less red?
- Which color filter would you use to study images from space?

PROMPT A DISCUSSION

ABOUT LIGHT AND COLOR ALL AROUND US

Provide diffraction glasses—another way for visitors to see the colors of light.

Encourage visitors to use the diffraction glasses to observe light sources in the exhibit space—and then at home. Remind them never to look directly at the Sun.

Explain that these special glasses are made with diffraction grating, a material with thin slits that bend and separate the different wavelengths of light, allowing the wearer to see different colors.

Astronomers like Dr. López-Morales use similar tools—called spectroscopes—to study light spectra that inform them about planets and other objects in outer space.

Diffraction glasses

ABOUT THE SCIENCE

A color filter is transparent and allows light to pass through it—but it will only allow light of the same color as the filter to pass through. Other wavelengths are absorbed. For instance, a blue filter will allow only blue light to show through. This will affect the colors of the pictures being seen in blue light.

This activity can also help visitors learn about colorblindness, or color vision deficiency. People with some common forms of color vision deficiency are unable to tell the difference between green and red or between blue and yellow.

It is important to know that colors do not appear the same for everyone.

FACILITATION TIPS

- The pictures of colorful shapes may be easiest and most interesting for visitors to interact with—particularly for children and family groups.
- At first, some visitors may not recognize the connection between the filters and the images from outer space. To

FACILITATION TIPS, continued

help make that connection, you could mention something like this:

"Here, in this nebula, there are many different substances that correspond to the colors (hydrogen, oxygen, nitrogen, etc.). Since it's sometimes difficult to focus on all these things at once, astronomers can use filters to limit their searches and help them identify and focus on specific substances."

- Before facilitating this activity, experiment with it yourself. This can help you anticipate visitors' questions and recommend ways for them to explore the different effects of the filters.

MAKE CONNECTIONS

Help visitors notice connections between Kamāl al-Dīn al-Fārisī and Mercedes López-Morales, such as these:

- **Al-Fārisī and López-Morales are scientists carrying out careful experiments to learn something new about our universe.**
- **Both scientists are interested in how light moves through a substance (we call this "a medium") to produce different colors. Al-Fārisī is looking at light moving through a raindrop. Dr. López-Morales is looking at light moving through a planet's atmosphere.**
- **The science of light and color is important to both scientists' discoveries.**

Sorting Scientists

Facilitate a game to help visitors learn about Kamāl al-Dīn al-Fārisī and Mercedes López-Morales

This activity draws visitors' attention to the lives and work of Kamāl al-Dīn al-Fārisī and Mercedes López-Morales. The game helps visitors learn about the scientists—where they are from, what their research is about, and more.

The "Sorting Scientists" game helps visitors make connections between the scientists and learning experiences included in the *Hidden No More* exhibit. It reinforces the exhibit's message that many kinds of people, often unknown to us, have helped us—and are helping us—understand the marvels of our own planet and planets far beyond ours.

MAIN IDEA

Visitors play a matching game with cards or magnets that display facts about Kamāl al-Dīn al-Fārisī and Mercedes López-Morales.

EXHIBIT COMPONENTS

- Two options for setting up this activity are provided:

  [Option 1] Set of face cards (1 card for Kamāl al-Dīn al-Fārisī and 1 card for Mercedes López-Morales) and fact cards (6 facts per scientist)

  [Option 2] Magnetic "Sorting Scientists" board and magnetic fact pieces (6 facts per scientist)

- Table large enough for the game to be spread out on it—and with space around it for the facilitator and up to four visitors.

Note: Assess the table height to be sure that all your visitors—including those who use wheelchairs—can reach it and see the cards.

TRY THE ACTIVITY

[Option 1] Card game. To begin, the facilitator places a picture card for al-Fārisī and a picture card for López-Morales face up on the table. The fact cards are placed facedown. This allows visitors to discover each fact one at a time, consider it, and place it next to the picture of the scientist to whom it connects.

1. As you turn each card over, try to match the fact with one of the scientists.
2. There are six fact cards for each scientist. How many can you match?

TRY THE ACTIVITY, continued

3. This is not a test—you can discuss the facts and ask for answers (or just for hints and clues before you make your choices)!

[Option 2] Magnetic game. Same as Option 1, but the facilitator can place the fact pieces on the table and invite visitors to place each fact in the matching scientist's column on the magnetic board.

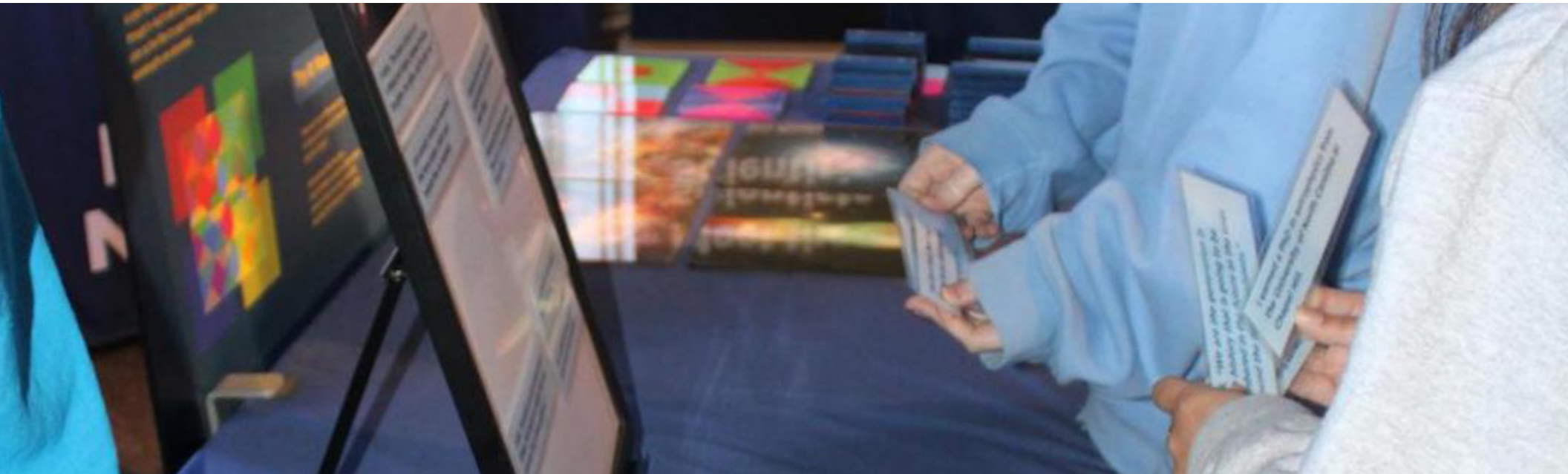
GUIDING QUESTIONS

- What clues helped you match the facts to the scientists? Did you see patterns (e.g., rainbows usually referred to Kamāl al-Dīn al-Fārisī) or notice that some facts probably happened long ago or more recently?
- Did you already know about these scientists before you came here today? (Guide the visitor to a related video, panel, or other resource in the exhibit that will help them learn more about a scientist who has particularly sparked their interest.)

FACILITATION TIPS

This facilitated activity can be played by one or more visitors at a time. A family or a small group of friends, for example, can have fun playing together—reading each card aloud and discussing it before making a choice.

While the game can be played at any time during a visit, students who tested it indicated they felt it was best played after visitors had experienced other parts of the exhibit first.



ANSWER KEY

Kamāl al-Dīn al-Fārisī

I discovered how rainbows form and observed that the color spectrum is made of light.

My explanation of how light is reflected and refracted to make rainbows is still considered largely correct.

I wrote, “The colors of the arc are different but related between the blue, the green, the yellow, and the dark red.”

I was a Persian Islamic scientist and mathematician.

I am credited with improving the experimental scientific method.

I discovered that rainbows are made when light is refracted and reflected by water droplets.

Mercedes López-Morales

I was born in Spain.

When I was a child, my favorite subject was math.

I earned a PhD in astrophysics from the University of North Carolina at Chapel Hill.

I said, “We are the generation in human history that is going to be remembered in the future as the ones who found the first exoplanets.”

I am currently looking for exoplanets that have oxygen, which could indicate they are habitable.

I said, “Knowledge brings peace of mind … and brings you down to Earth and makes you more conscious of what you have and what you don’t have.”

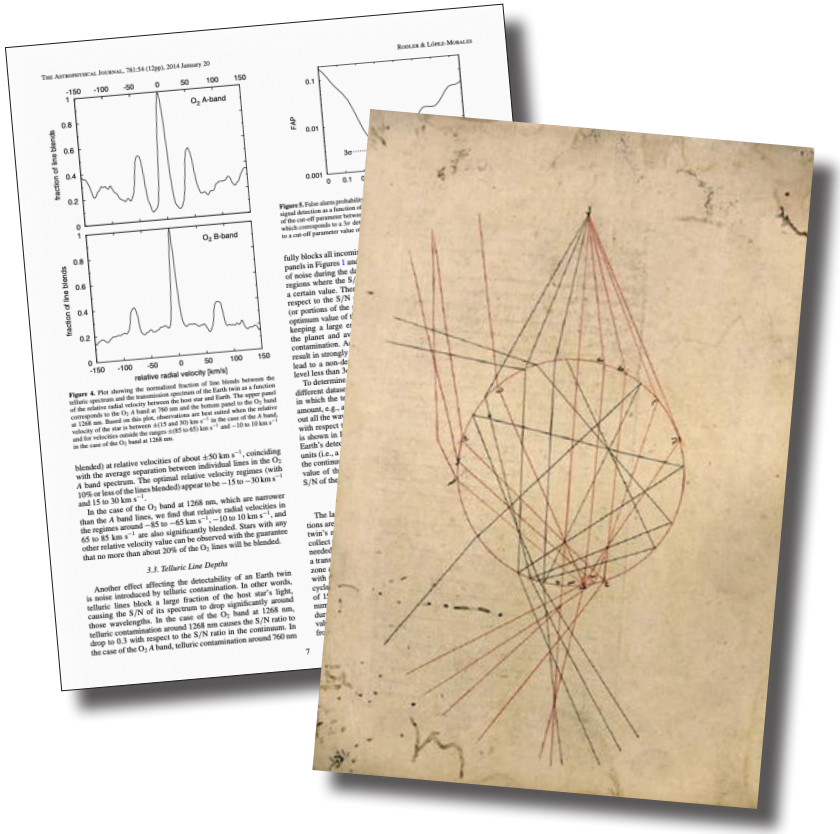
PROMPT A DISCUSSION

ABOUT THE CONTRIBUTIONS OF MANY PEOPLE TO USEFUL THINGS WE KNOW

Science is made of building blocks through history, with each new discovery extending the work of the scientists who came before. Often, we know about some very famous scientists, while the stories of many other discoverers and innovators are in the shadows.

Kamāl al-Dīn al-Fārisī concluded his book on optics at the beginning of the 14th century. Now, at the beginning of the 21st century, Mercedes López-Morales is able to study exoplanets with spectroscopy because of the knowledge about light and color that scientists like al-Fārisī gained through the years.

Perhaps, centuries from now, people will live on a habitable exoplanet because of Dr. López-Morales's discoveries! Can you imagine that?!



Left: A page from "Feasibility Studies for the Detection of O_2 in an Earth-like Exoplanet" (2014) by Florian Rodler and **Mercedes López-Morales**.

Right: A page from **Kamāl al-Dīn al-Fārisī**'s work *Tanqīḥ al-Manāẓir, or The Book of Correction of Optics for Those Who Have Sight and Mind* (1309). More commonly called *The Revision of the Optics*, this book includes al-Fārisī's discoveries about rainbows.

Animated Video

Kamāl al-Dīn al-Fārisī (1267—1319)

MAIN IDEA

Visitors learn about the life and significant discoveries of Kamāl al-Dīn al-Fārisī by engaging with a short, animated video.

EXHIBIT COMPONENTS

- ELO touchscreen video monitor and Brightsign media player
- Information panel with table clamps

GUIDING QUESTIONS

- What happens when light is reflected? Where does the light beam go? (The light beam hits something and bounces off.)
- When light is refracted, what happens to the beam? (The beam moves through something, slows down, and is bent.)
- What did you find most interesting about Kamāl al-Dīn al-Fārisī's life or experiments?

GUIDING QUESTIONS, continued

- Kamāl al-Dīn al-Fārisī created experiments to answer questions he had about how rainbows form. What questions about rainbows would you want to explore?

MORE TO LEARN

ABOUT KAMĀL AL-DĪN AL-FĀRISĪ

Al-Fārisī was born in Persia (modern-day Iran) in an age of great scientific discovery and innovation in central Asia. He became one of the most important physicists and mathematicians of his time.

Al-Fārisī wanted to understand how we see light and how light illuminates objects. As a student, he read *The Book of Optics* (*Kitāb al-Manāẓir*), written centuries before by Ibn al-Haytham (c. 965–c. 1040). *Optics* described Ibn al-Haytham's pioneering work on reflection and refraction, how the eye sees, and other topics related to light.

Encouraged by his teacher, Qutb al-Dīn al-Shirāzī (1236–1311), al-Fārisī spent years on his own book, *The Revision of the Optics* (*Tanqīh al-Manāẓir*). Al-Fārisī finished *The Revision of the Optics* in 1309.

Al-Fārisī did more than revise, or correct, *Optics*—he added to it. A notable addition was his explanation of how sunlight and raindrops form rainbows, still considered to be largely correct.

The ancient Greek scientist Aristotle (384–322 BCE) and many scientists after

(continued on next page)

MORE TO LEARN ABOUT KAMĀL AL-DĪN AL-FĀRISĪ, continued

him, including Ibn al-Haytham and al-Shirāzī, tried to understand rainbows. But this phenomenon was still a puzzle when al-Fārisī started work on the problem.

Like Ibn al-Haytham, al-Fārisī used experiments and scientific models to test his ideas. Both scientists also used a camera obscura, a darkened room with a hole allowing a focused beam of light to enter.

In al-Fārisī's experiments, a glass sphere filled with water represented an atmospheric water droplet. He observed the angles of the beam of light as it interacted with the sphere—and discovered that sunlight is refracted twice and reflected once by each droplet. This process causes the white light of the Sun to separate into the colors of the rainbow.

With his knowledge of geometry, al-Fārisī was able to give us "the very first correct mathematical explanation of the rainbow" (Al-Khalili, p. 159).

Coincidentally, at almost the same time, in another part of the world, the German physicist Theodoric of Freiberg (c. 1250–c. 1310) conducted a similar experiment and also explained how rainbows are formed. Like al-Fārisī, Theodric referred to Ibn al-Haytham's prior work on optics.

Three hundred years later—using prisms, rather than spheres, in a darkened room—Isaac Newton (1643–1727) conducted experiments that furthered our knowledge of the color spectrum.

Al-Fārisī also made important contributions to mathematics. His ideas about number theory (the study of whole numbers) are still used today.

Documentary Video

Mercedes López-Morales (born in 1973)

MAIN IDEA

Visitors learn about contemporary scientist Mercedes López-Morales, including what inspires her to learn and why it is important for girls to "see" themselves in science and mathematics, by engaging with a short documentary video.

EXHIBIT COMPONENTS

- ELO touchscreen video monitor and Brightsign media player
- Information panel with table clamps

GUIDING QUESTIONS

- What inspired Dr. López-Morales to study astrophysics?
- What is an exoplanet and why are people like Dr. López-Morales interested in studying them?
- What did you find most interesting about Dr. López-Morales?

GUIDING QUESTIONS, continued

- If you could have lunch with Dr. López-Morales, what questions would you have for her?
- What questions do you have about planets in our solar system and beyond?

MORE TO LEARN

ABOUT MERCEDES LÓPEZ-MORALES

Mercedes López-Morales is an astrophysicist with the Smithsonian Astrophysical Observatory, part of the Center for Astrophysics, Harvard/Smithsonian.

As a young person, Dr. López-Morales loved math, but she didn't know that she would make a career with it. As a university student, she was given an opportunity to work with a large-scale telescope and that's when she became hooked on astrophysics, a science focused on the chemistry and physics of materials in space. Now she works to detect and understand the components of atmospheres around exoplanets.

Dr. López-Morales asks questions like, "What if we find oxygen in another planet's atmosphere?" She believes that we shouldn't be afraid of what we might discover—scientists are just trying to understand the universe and explain how things work.

Dr. López-Morales wants students—especially girls—to know that "Anybody can do this (work)." She wants girls to know that this is a science where they belong.

Virtual Reality Experience

Optical Experimenter
Kamāl al-Dīn al-Fārisī

MAIN IDEA

Experience 14th century Persia as you visit the laboratory of Kamāl al-Dīn al-Fārisī and help him conduct an experiment to discover how rainbows are formed.

Participants will be guided through experimental steps as they use their hands to move objects, such as mirrors and glass spheres, into different positions to reflect and refract a beam of sunlight. Participants can sit or stand to interact with this activity.

EXHIBIT COMPONENTS

- Oculus Quest 2 headset with case
- Round floor mat with feet (for standing use or with a chair in the center)
- Charging cord
- Sanitizing wipes

EXHIBIT COMPONENTS, continued

Note: Make a chair available for visitors who will need to sit down to take part in this activity. For example, some visitors may rely on a cane or walker to steady themselves when they are standing. Being provided a chair will allow them to use both of their hands to engage with the VR experience.

GUIDING QUESTIONS

- Tell me how you helped Kamāl al-Dīn al-Fārisī with his experiment. What did you discover?
- What was the coolest part of the experience, in your opinion?
- If you could go back into al-Fārisī's lab and try your own experiment there, what would you want to study? Would you want to try another experiment with rainbows—or would you want to study something else?

MAKE CONNECTIONS

TO OTHER EXHIBIT RESOURCES

Ask a guiding question: "If you could go back into al-Fārisī's lab and bring something from the *Hidden No More* exhibit to share with him, what would you bring? What do you think his reaction would be?"

Virtual Reality Experience

Exoplanet Hunter
Mercedes López-Morales

MAIN IDEA

Join Mercedes López-Morales in her observatory to help her find distant planets orbiting stars, also known as exoplanets.

Using their hands, participants help Dr. López-Morales gather data about the chemical elements found around newly discovered exoplanets. Participants can sit or stand as they "catch" the signature spectrum of oxygen, methane, or water—components needed for life on a planet.

EXHIBIT COMPONENTS

- Oculus Quest 2 headset with case
- Round floor mat with diagrams of foot positions (for standing use, or for use with a chair in the center)
- Charging cord
- Sanitizing wipes

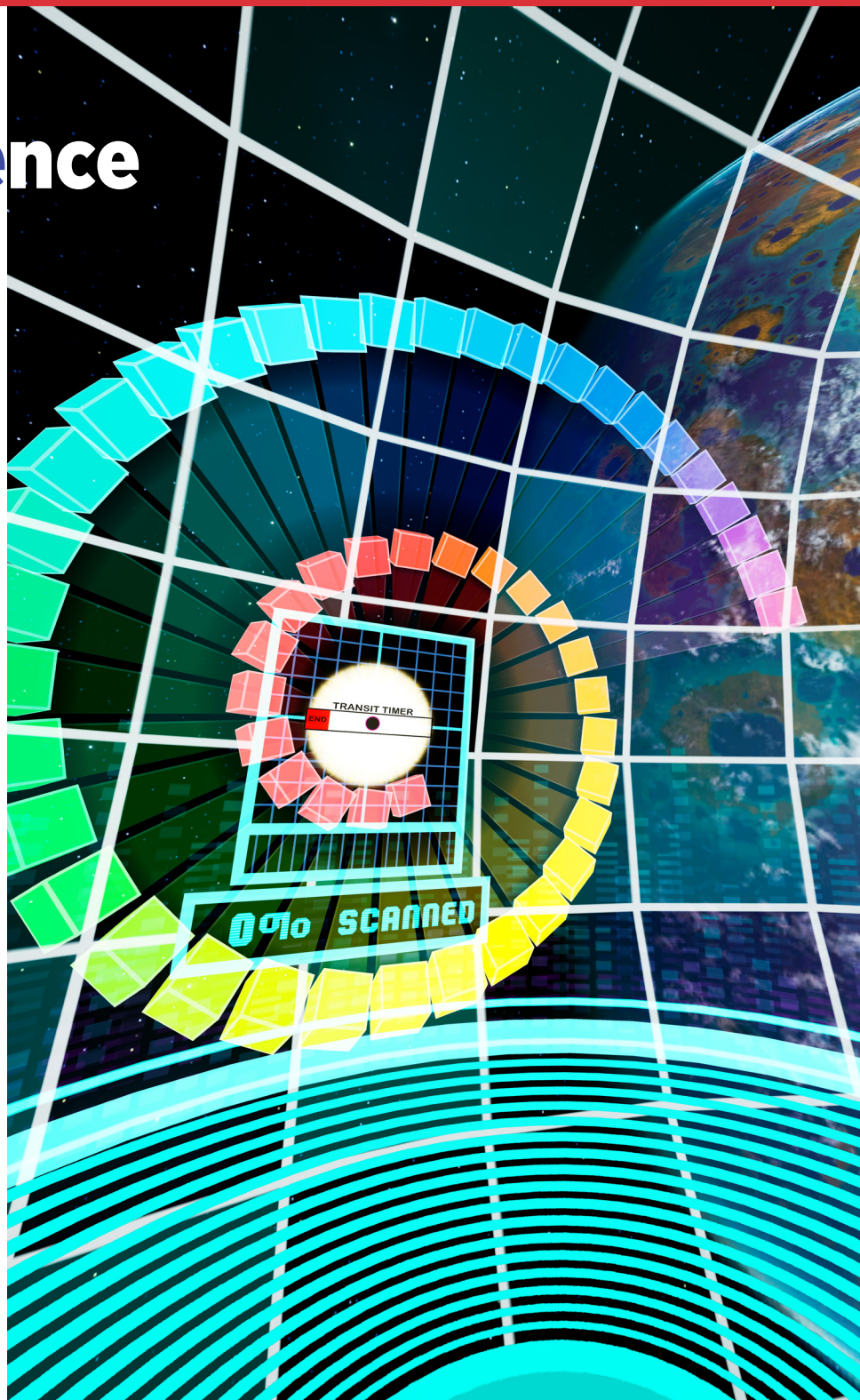


EXHIBIT COMPONENTS, continued

Note: Make a chair available for visitors who will need to sit down to take part in this activity. For example, some visitors may rely on a cane or walker to steady themselves when they are standing. Being provided a chair will allow them to use both of their hands to engage with the VR experience.

GUIDING QUESTIONS

- Tell me what you did in Dr. López-Morales's observatory? What was the most interesting (or coolest) part for you?
- A planet's atmosphere needs certain materials for life to exist there. How do these faraway discoveries help us understand our Earth's atmosphere?
- Researchers hope these kinds of discoveries will lead us to habitable planets. If you found a distant planet with oxygen, water, and methane in the atmosphere, what would you want to know about it? How would you find out?

MAKE CONNECTIONS

TO OTHER EXHIBIT RESOURCES

The chemical spectrum of an exoplanet's atmosphere is like a "fingerprint," a pattern that shows scientists exactly which gases are present. Encourage visitors to try the "Studying Spectra" activity and see if they can match the spectra, or wavelengths of light, from a distant star to discover certain elements and molecules in the surrounding atmosphere—like Dr. López-Morales.

Sources

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