

INSPIRING THE NEXT GENERATION OF
ASTRONAUTS, SCIENTISTS, AND SPACE ENTHUSIASTS



IN SATURN'S RINGS

TAKE THE
JOURNEY

IN MEMORY OF STANLEY KUBRICK AND CARL SAGAN

EDUCATOR GUIDE

IN SATURN'S RINGS

EDUCATOR GUIDE

INTRODUCTION

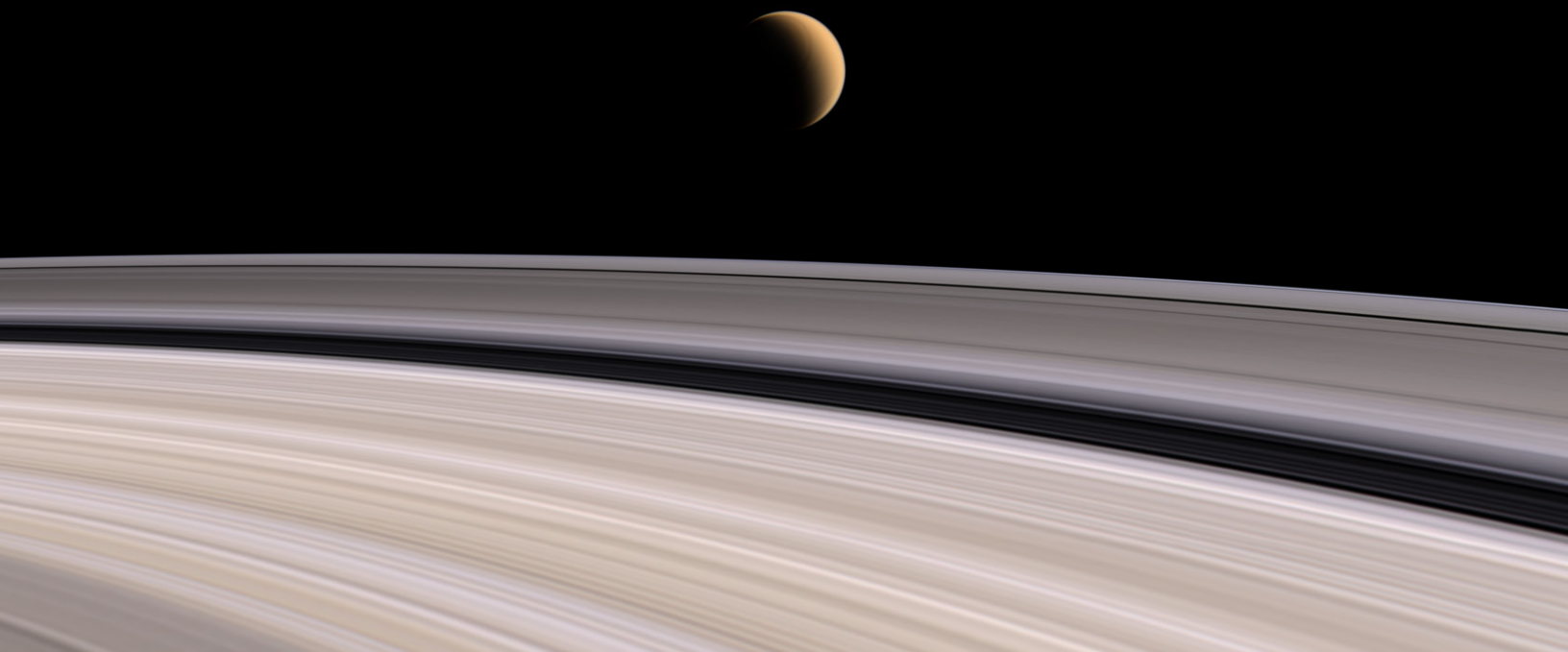
by Andrew Chaikin, author of *A Man on the Moon*

We are born to explore. This common thread links us with our prehistoric ancestors who first crossed the land bridge from Asia to begin humanity's transformation into a global species. Today, our explorations stretch to the farthest reaches of the visible universe, thanks to our robotic emissaries like the Cassini Saturn orbiter and the Hubble Space Telescope, and the brilliant minds who create and operate them.

The sight of an alien landscape, undeniably strange yet sometimes uncannily familiar, has become almost an everyday event. And yet, the spectacular images of planets, moons, nebulae, and galaxies taken by our far-travelling probes and orbiting telescopes continue to amaze and inspire.

That is the power of *IN SATURN'S RINGS*.

The film is both an exploration and an evocation. Like space exploration itself, it touches us not only intellectually, but emotionally and even spiritually.



IN SATURN'S RINGS makes a great classroom field trip experience because it engages students on many levels – from the beauty of our universe to the uniqueness of our Earth – via real pictures from space exploration.

This Educator's Resource Guide is designed for students grades 4 through 8. Using *IN SATURN'S RINGS* for illustration, it provides hands-on lessons, experiments, and observational activities designed to educate students about space exploration. Each activity includes ideas for implementing the lessons, expansion activities, and additional resources, as well as correlations to national standards.

A table correlating the activities to the **Next Generation Science Standards** is provided at the end of this guide, as well as a list of books and websites for additional study.

We encourage cross-cultural synthesis by engaging teachers (i.e. English, Art, and Music) to create additional activities for students such as:

- *Writing a poem, review, or short story about IN SATURN'S RINGS;*
- *Drawing or painting a picture inspired by the film;*
- *Picking a song that reminds you of the film or selecting a new soundtrack for the film.*

In keeping with the broad intellectual, emotional and spiritual aspects of *IN SATURN'S RINGS*, this Educator Guide will engage students on each level of the STEAM curriculum (science, technology, engineering, arts, and math).

THE INCREDIBLE JOURNEY

Fly through space and explore the wonders of the Universe as science meets art on the giant screen! *IN SATURN'S RINGS* is a groundbreaking giant-screen adventure that takes audiences on a journey of the mind, heart, and spirit, from the Big Bang to the awe-inspiring rings of Saturn.

The film is created entirely of more than 1.2 million stunning images of Earth, the Milky Way, and the Moon taken by Hubble, Cassini, and other space telescopes looking deep into the past. In some scenes, a single photograph is used per frame, but many frames are a giant collage of thousands of photographs seamlessly joined. The film is animated to full-motion without CGI, 3D modeling, or simulations.

IN SATURN'S RINGS is an awe-inspiring experience that connects us to the wonders of the Universe.

TABLE OF CONTENTS

Lesson 1: Take a Solar System Walk.....	4
Lesson 2: Saturn by Numbers	5
Lesson 3: Make Your Own Craters	6-7
Lesson 4: Pixel This!.....	8-9
Lesson 5: What is Light Pollution?.....	10-11
Space Key Word Search.....	12
Space Key Word Definitions.....	13
Additional Resources and Links.....	14
FAQs/About the Filmmaker.....	15
Next Generation Science Standards	16

OVERVIEW

Our Solar System is vast and wondrous. We are so tiny in comparison, and can see only a few planets as points of light in our sky. We need a way to appreciate our System's immense size and Earth's place in it. *IN SATURN'S RINGS* artfully demonstrates the huge distances between planets. But to get a real, physical sense of the Solar System and the relative distances between planets, you can create this walkable scale model of the Solar System. Scale models allow us to explore and examine things that are too large to comprehend otherwise.

Starting with a balloon as the Sun, walk to each planet using a "pace" (2 normal steps, about one meter) as a measure, and place a marker for each planet as you go. The final walk will be about 600 meters (less than half a mile). The entire Solar System tour will take about 45 minutes round-trip.

MATERIALS

- Round balloon that can be blown up to 14 cm in diameter
- Solar System Scale Model Distances chart (below)
- Sign-making materials (cardboard, pens or crayons) for planet signs
- Sticks or stiff wires to hold the planet signs
- Tape
- Metric ruler or meter stick

Scale Model Planet Diameter

Planet (1/10 billion scale)	Scale Model (mm)	Actual (km)
Mercury	0.5	4,880
Venus	1.0	12,100
Earth	1.0	12,800
Mars	0.5	6,790
Jupiter	14	142,980
Saturn	12	120,540
Uranus	5.0	51,120
Neptune	5.0	49,530

Solar System Scale Model Distances

Planets (1/10 billion scale)	Paces between Objects (meters)	Total Paces from Sun to Each Planet	Average Distance from Sun (meters)
Sun to Mercury	6	6	60,000,000,000
Mercury to Venus	5	11	110,000,000,000
Venus to Earth	4	15	150,000,000,000
Earth to Mars	8	23	230,000,000,000
Mars to Jupiter	55	78	780,000,000,000
Jupiter to Saturn	65	143	1,430,000,000,000
Saturn to Uranus	144	287	2,870,000,000,000
Uranus to Neptune	163	450	4,500,000,000,000



If you cannot leave the classroom, take a virtual trip! Visit "If the Moon Were Only 1 Pixel" https://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html

PROCEDURE

Before the Walk (Set-up)

1. **Choose the walk area.** The 600-meter area does not have to be in a strictly straight line, and it doesn't need to be all open space or outside—it can start in a soccer field and continue through parking lots, sidewalks and even hallways.
2. **Practice walking along a meter stick on the floor**, to make sure that your steps are even. Ensure your "pace" is two normal steps per meter. *Teachers: Identify good "pacers" for the walk.*
3. **Make planet signs**, attaching them to sticks or stiff wires for placing in the ground. *Teachers: Assign each student or small group responsibility for a planet. If you have time, students can research their planets so they will be able to give facts about them during the walk.*
4. **Make the Sun:** Blow up a round balloon to 14 cm diameter to represent the Sun. *Optional: Make planets at the same scale. For example, use a mustard seed for Earth and a small marble for Jupiter. The Scale Model Planet Diameter table to the left of this activity will help you.*

The Walk

Allow about 45 minutes for this activity.

1. Bring the Sun balloon, tape, planet signs, and Solar System Scale Model Distances chart (left) outside to the activity area.
2. Tape the "Sun" to a fixed object, such as a doorway or post.
3. Beginning at the Sun, "pace" to each planet, and place the sign for it as you go. For the number of paces, use the Solar System Scale Model Distances chart to the left. When you get to Earth, estimate where Saturn will be in the model. Also, between Mars and Jupiter, remember that you are walking through the Asteroid Belt!

DISCUSSION

1. What surprised you most about the scale model?
2. How fast do you think a spacecraft would travel in this model? *Answer: 0.6 cm/hr*
3. How does this model help you understand the challenges of space travel?
4. Would you like to walk to the next closest star (Proxima Centauri) from the Sun? Pack your bag! It would be over 4000 km away in this model. That's the distance from Boston, Massachusetts, to Seattle, Washington!

HOW MUCH DO YOU KNOW ABOUT SATURN?

Use the Saturn Data Chart below to answer these questions and increase your numeric knowledge of Saturn, its rings, and its distance from the Earth.

Please use a separate sheet of paper for your answers.

1. How many Saturn days occur during one Earth day?

2. Arrange the rings in order of distance from Saturn.

- Which ring is the closest to Saturn?
- Which ring is the farthest from Saturn?
- Which ring is the widest?
- Which ring is the narrowest?

3. Calculate the distance between the orbits of Earth and Saturn.

4. Calculate the mean circumference of each ring. How long would it take a spacecraft traveling at 56,000 km/hr to go around each ring?

5. Traveling at the speed of light, radio transmissions from the Cassini spacecraft take between 1 hour 14 minutes and 1 hour 24 minutes to get to Earth. (The transmission time changes, based on the distance between planets as they move in their orbits.) About how long would it take for mission controllers to know if a command was executed properly, after it was sent to Cassini?

SATURN DATA CHART

Planet	Day Length	Mean Orbit
Earth	23 hours 56 minutes	149,589,262 km
Saturn	10 hours 14 minutes	1,426,666,422 km

Ring - Named alphabetically in the order discovered	Radii (km) - Measured from planet center to start of ring	Width (km)
A	122,050-136,770	14,600
B	91,980-117,580	25,500
C	74,490-91,980	17,500
D	66,970-74,490	7500
E	180,000-480,000	300,000
F	140,224	30-500
G	166,000-174,000	8000

Ring	Mean Circumference Rounded to nearest km	Time to Travel in Spacecraft Rounded to nearest hour
E	1,036,200	19
G	533,800	10
F	440,303	8
A	406,347	7
B	329,009	6
C	261,358	5
D	222,092	4

Results by Ring (for Question #4)

- Earth Day: 23 hr 56 min = 23.93 hr
Saturn Day: 10 hr 14 min = 10.23 hr
Saturn Day/10.23 hr = 2.34 Saturn days per each Earth day
1,426,666,422 km (Saturn's mean orbit) - 149,589,262 km (Earth's mean orbit) = 1,277,077,160 km
(Nearest to farthest) D C B A F G E
- Nearest ring: D; Farthest ring: E; Widest ring: E; Narrowest ring: F; Mean Circumference: Add both radii and divide by 2 for mean radius, then multiply by pi (3.14); Travel time around each ring: Divide circumference (km) by 56,000 (km/hr).
(For individual results, see Results by Ring table on the right)
- Double the time; the transmission would have to travel to Cassini and back. The time would be between 2 hr 28 min and 2 hr 48 min.

ANSWER KEY (Hey! No cheating!)

OVERVIEW

Looking at the Moon and planets, we can see surfaces pitted with craters of all different sizes and shapes. Almost every solid object in the Solar System shows evidence of craters. Most craters result from impacts from rocky objects like meteors or asteroids. The size and speed of the impactor determines how a crater looks.



Making craters is easy! To simulate crater formation, fill a shallow pan with flour; top with chocolate drink mix, then drop (don't throw!) rocks into the pan. If rocks are not an option, substitute marbles or balls of various sizes. You can experiment with different sizes, speeds, and impact angles—comparing the craters' diameters, depths, and rays [streaks radiating outward from the crater]. The entire activity lasts about 45 minutes.

MATERIALS

- 1 five-pound bag of flour
- 1 can of chocolate drink mix powder (not cocoa powder, which clumps and darkens flour)
- Shallow basin (foil roasting pan, dishpan, or cardboard box)
- Sifter
- 3 rocks of different sizes: about the size of a pea, a marble, and a small lemon.
- Metric ruler or meter stick
- Plastic spoon to retrieve rocks
- Pencil
- Data Collection Table (p. 7)
- Newspaper to protect floor
- Broom

Teachers: If a class rather than an individual is performing this activity, you will only need one broom and can of chocolate powder for the whole class, but you'll need the rest of the items on the list for each team. The chocolate powder can be subdivided among the teams, in small containers.

Try the procedure yourself beforehand so you know what will happen. If in a classroom setting, prepare the class by talking about craters, showing photos of the Moon and other cratered bodies, and asking how they think craters form and what affects the size of the craters. Prior to setting up team "crater stations," demonstrate the procedure.

PROCEDURE

You can do this activity outside if it's not windy, eliminating the need for newspaper and broom.

1. **SAFETY FIRST!** No rock throwing. Cover the floor with newspaper since flour is very slippery.
2. Prepare your "crater station" - fill basin about 10 cm deep with flour. With sifter, make a light layer of chocolate drink powder on flour's surface (to make the "crater" more visible). The flour represents the Moon surface; rocks will represent meteoroids.
3. Drop (do not throw!) your "meteoroid" onto the "Moon" surface. (Actual meteoroids travel 6,000 times faster than the rocks you drop!) Observe the impact.
4. Experiment to find out how the size of the meteoroid affects the size of the crater:
 - a. Make 3 craters with each of your rocks, all dropped from the same height (9 drops total). You can use a meter stick or your height as the constant. Why is it important to use the same drop height? [Any changes in crater size will be due to different rock size.]
 - b. With the metric ruler, carefully measure the crater diameter in centimeters after each drop. Include crater depth and measurements of rays, if appropriate.
 - c. Carefully remove the rock with the spoon after each measurement. (Doing so ahead of time may deform the crater; you will need to remove the rock for depth measurement).
5. If you need more surface area, smooth the surface by gently shaking the basin a few times to level the flour. If necessary, sift more chocolate powder on top.
6. Use the Data Collection Table (p. 7) to record your results.
7. Try the optional cratering experiments and explore more cratering activities on the next page.



TEAM MEMBERS: _____

Data Collection Table (All values in centimeters)

		Size of Meteoroid		
		Small Rock	Medium Rock	Large Rock
First Drop	Crater Diameter			
	Crater Depth			
	Ray Length			
Second Drop	Crater Diameter			
	Crater Depth			
	Ray Length			
Third Drop	Crater Diameter			
	Crater Depth			
	Ray Length			

OPTIONAL CRATERING EXPERIMENTS

Here are a few more cratering experiments you can try – no data sheet needed:

- Drop your meteoroid from different heights. How do the craters differ?
- Carefully toss your meteoroid at an angle onto your moon surface. What shape crater do you expect to see? What shape crater occurs? [Round craters always occur, whatever the impact angle or shape of the impactor!]
- Simulate a “crater chain” on your flour moon surface by dropping a handful of small gravel. [A crater chain occurs when a meteoroid breaks up, due to gravitational forces, before impact. Crater chains are visible on moons and even on Earth, as seen from space, as a line of circular lakes or holes.]

DISCUSSION

1. What do you observe in the data on your Data Collection Table above? Does the size of the meteoroid change the size of the crater? [Data will vary, but generally larger rocks make larger craters.] Also, if measured, how does meteoroid size affect crater depth and length of rays?
2. Discuss the difference between meteoroids [rocks in space], meteors [meteoroids glowing from atmospheric friction as they fall toward a moon or planet with an atmosphere], and meteorites [meteoroids that reach the surface without burning up in the atmosphere].
3. Does Earth have craters? Yes! Earth has many craters, some of which are impact craters (not volcanic). We don't see them all because Earth's weather erodes surface features over time. Craters on the Moon stay sharp because it has no atmosphere.

More advanced students may also perform the experiment at this site:

www.ucmp.berkeley.edu/education/dynamic/session2/sess2_act4.html

Additional information about cratering activities can be found at:

- https://down2earth.eu/impact_calculator/planet.html?lang

OVERVIEW

For years, scientists have been using digital satellite images to study objects from space. More recently, digital photography has evolved so that most people carry sophisticated digital cameras in their pockets via mobile phones. How are these images made?

Using simple numeric processing, this activity gives you a basic understanding of how a digital camera works and how the images from *IN SATURN'S RINGS* come to life.

A digital camera uses a lens to project an image onto a light-sensitive surface in a dark chamber. Its electronic sensor then records the image. The sensor is like many tiny solar cells that convert light into electrical energy. The camera's built-in computer logs how much light hits each cell, or "pixel," by recording the electrical charge produced by the cell. If a pixel receives more light, the computer will record a higher number; if it receives less light, it will record a lower number. The digital record looks something like Figure 1 (p. 9).

Once the digital data is recorded, a computer can translate the number from each pixel into a color value, a lot like painting by numbers. For example, a zero may be assigned black, and a nine may be assigned white. In this way, the numeric array in Figure 1 (p. 9) can become an image of Saturn, as we see in Figure 2 (p. 9). The same technique was used by NASA scientists when receiving the first data from the Mariner mission to Mars: <https://photojournal.jpl.nasa.gov/catalog/PIA14032>

As you can see, this image is not as amazing as those seen in *IN SATURN'S RINGS*. The difference between this image and those in the film is resolution. This image has a small amount of data, or low resolution. It is composed of 36 columns and 28 rows (36 X 28) or 1008 pixels. Many of the images from *IN SATURN'S RINGS* have more than 9 billion pixels! This higher resolution makes the images more than 20,000 times more detailed than Figure 2.

If images from space exploration missions are taken with black and white digital cameras, then how do we get color images from them? To make a color image, pictures are taken through red, green and blue filters. The three separate images are colored, then digitally combined to produce a spectacular full-color image that we may all enjoy.



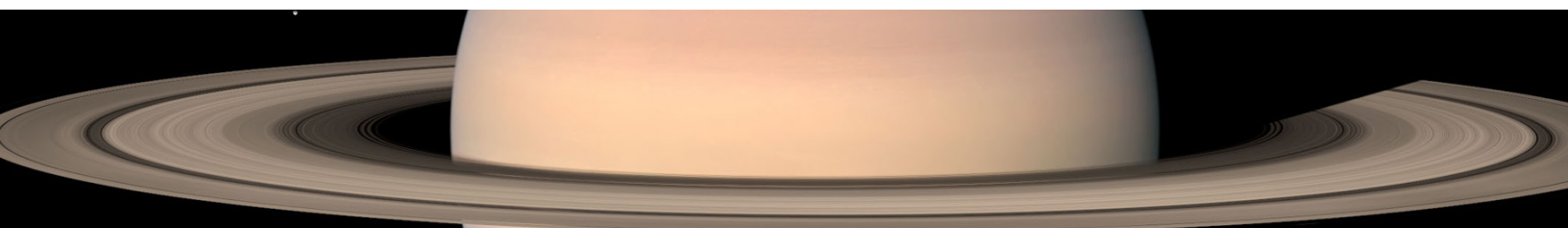
Photo courtesy of Mark Wagoner Photography.

MATERIALS

- Data Sheet provided on p. 9.
- Downloadable Data Sheet at <https://insaturnsrings.com/educator-guide>

PROCEDURE

1. Reveal the image of Saturn in the Data Sheet on p. 9. This is like "painting by numbers." Print the data sheet and shade in all the squares accordingly:
 - 0 = Black
 - 1 = Dark Grey
 - 2 = Light Grey
 - 3 = White
2. After completing the Data Sheet from p. 9 by hand, if you have Microsoft Excel you can use it on your computer to color the image really fast:
 - a. Open the downloaded Data Sheet on your computer.
 - b. Select all of the numbers in the worksheet.
 - c. Using the Conditional Formatting command (on the Home ribbon), select Color Scales. This option will let you automatically color each numbered cell with the color you've assigned the number.
 - d. To choose the colors for the minimum and maximum values, select More Rules from the Color Scales screen.
 - e. Leaving the Style as 2-Color Scale, try black for the Minimum value and light yellow for Maximum value.
 - f. Press OK to see what happens! Zoom out to sharpen the resulting image.



OVERVIEW

Some of the most breathtaking images in *IN SATURN'S RINGS* are views of the night sky from Earth. These beautiful starscapes were seen by everyone for thousands of years, inspiring great artists, musicians, and scientists. Far from city lights, you may still enjoy seeing the Milky Way galaxy stretch across the night sky. Unfortunately, since the late 1800's invention of electric streetlights, people have slowly seen less of the night sky.

Through observation and discussion, this activity allows you to understand the nature and causes of light pollution and to explore its solutions. It also encourages both students and teachers to explore the night sky.

While we need lights for safety and security, the misdirected overuse of artificial outdoor lighting is a growing problem. There are three basic types of light pollution:

- **Glare** occurs when bright lights are directly visible and interfere with seeing; e.g., problems seeing when riding in the car at night. (Why is this worse on a rainy night?)
- **Light Trespass** happens when unwanted light crosses onto someone else's property; e.g., light from a neighbor's house or a streetlight shining in your bedroom window.
- **Sky Glow** is the upward directed and reflected light often visible above urban areas; e.g., orange glow in the sky, especially visible on a cloudy night, or the bright glow around a convenience store.

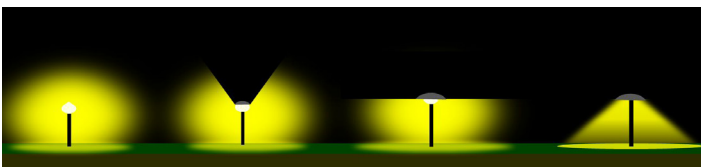
Along with hiding the night sky, each type has other costs:

Ecosystem Disruption: For wildlife, excessive light alters predator/prey relationships and confuses migration and sleep patterns. For plants, excess light alters the normal patterns of light and dark needed for normal growth.

Human Health Problems: Studies show light pollution affects human health, whether by consequences of glare, disruption of melatonin production, or changes in sleep patterns. Fatigue, stress, obesity, and some cancers may also be linked to light pollution.

Wasted Energy: Any light shining where it is not wanted or needed wastes energy and money. Also, most existing streetlights were not designed for energy efficiency.

How can we cut light pollution but still provide useful light? Combine directional shielding with energy-efficient lighting. Unshielded lights lose energy in all directions, while directional shielding shines light only where it's needed, saving energy at the same time.



Examples of streetlights from unshielded to full cut-off fixtures.



Example of night sky with no light pollution. Photo courtesy of Colin Legg Photography. Eleven day, eleven night, five camera timelapse of night sky in Australian Outback. 2014

PROCEDURE

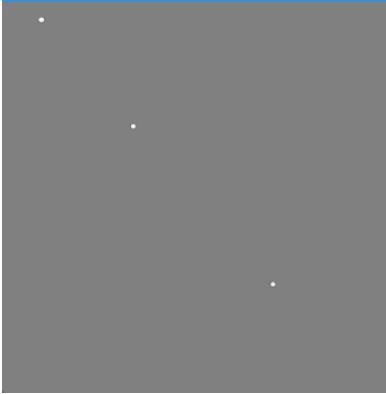
Teachers: This lesson can be completed in two parts, with extra time for nighttime observations between days.

- **Discuss the following questions:**
 1. What are your reactions to the “Night Sky” section of *IN SATURN'S RINGS*?
 2. Have you ever seen the Milky Way? Why have most people in developed countries never seen the Milky Way?
 3. Give examples of works by artists, poets, or musicians who've been influenced by seeing the stars.
- **Explore the galleries in The World at Night site:** <https://twanight.org/galleries/>
Teachers: Divide students in groups to look at images from different areas of the world.
- **Observe the night sky at your home**
 1. On a clear night, use the Dark Sky Chart (p.11) to analyze the quality of the night sky at your home.
 2. Select the image that most closely represents the number of stars you see; the darker the sky, the more stars will be visible.
 3. If you can only see the stars shown in image 1, the sky quality is low and many stars are being blocked by the artificial light.
- **Analyze your results**
Teachers: Tabulate and chart students' night-sky observations - how many students picked images 1, 2, or 3?
- **Answer the following questions:**
 1. What problems did you encounter when making observations?
 2. Identify the three different types of light pollution that you can see. How can you minimize each type of light pollution?
 3. Discuss the benefits of and problems with different types of outdoor lights and streetlights: exposed lamp, shielded, or full cut-off.

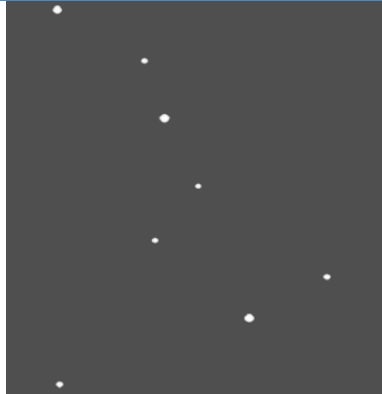
DARK SKY CHART

Which image most closely represents the number of stars you see?
The darker the sky, the more stars will be visible.

Big Dipper Star Chart: Use in Summer or Fall - look to the North.



1

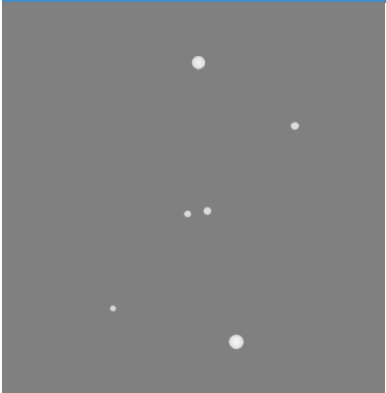


2



3

Orion Star Chart: Use in Winter or Spring: - look to the South.



1



2



3

More Light Pollution (too much artificial light)

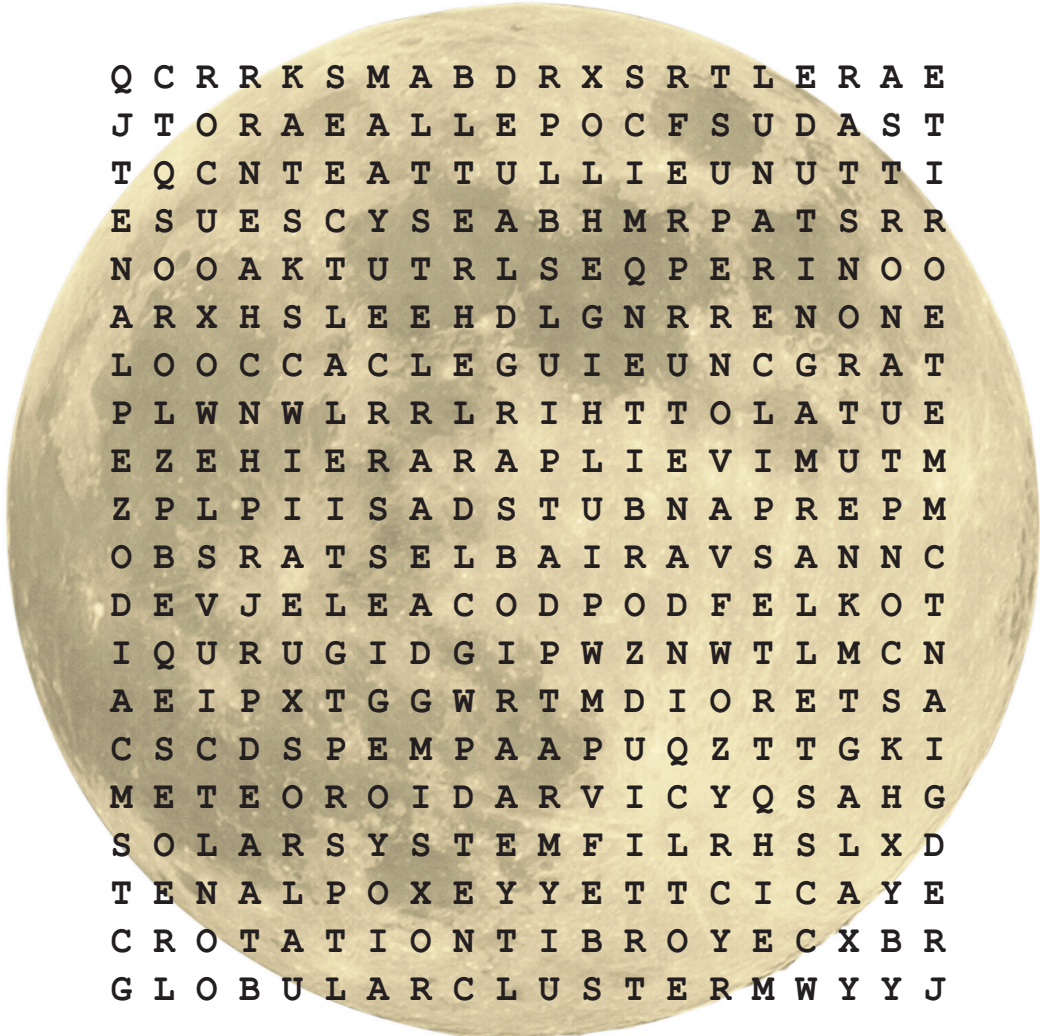
Less Light Pollution (no artificial light)

YOU CAN HELP!

- Encourage your neighbors and local businesses to adopt good lighting practices.
- Participate in Globe at Night www.Globeatnight.org, or learn more about light pollution through the International Dark Sky Association at www.darksky.org
- Contribute to a citizen science data collection about light pollution. Look for downloadable free apps such as “Dark Sky Meter” (iPhone) or “The Loss of the Night” (Android).

SPACE KEY WORD SEARCH

NAME _____



Q C R R K S M A B D R X S R T L E R A E
J T O R A E A L L E P O C F S U D A S T
T Q C N T E A T T U L L I E U N U T T I
E S U E S C Y S E A B H M R P A T S R R
N O O A K T U T R L S E Q P E R I N O O
A R X H S L E E H D L G N R R E N O N E
L O O C C A C L E G U I E U N C G R A T
P L W N W L R R L R I H T T O L A T U E
E Z E H I E R A R A P L I E V I M U T M
Z P L P I I S A D S T U B N A P R E P M
O B S R A T S E L B A I R A V S A N N C
D E V J E L E A C O D P O D F E L K O T
I Q U R U G I D G I P W Z N W T L M C N
A E I P X T G G W R T M D I O R E T S A
C S C D S P E M P A A P U Q Z T T G K I
M E T E O R O I D A R V I C Y Q S A H G
S O L A R S Y S T E M F I L R H S L X D
T E N A L P O X E Y Y E T T C I C A Y E
C R O T A T I O N T I B R O Y E C X B R
G L O B U L A R C L U S T E R M W Y Y J



asterism
asteroid
astronaut
black hole
celestial sphere
circumpolar
comet
constellation
ecliptic
exoplanet
galaxy
globular cluster

gravity
light year
lunar eclipse
meteor
meteorite
meteoroid
nebula
neutron star
open cluster
orbit
planet
pulsar

quasar
red giant
red shift
rotation
satellite
solar eclipse
solar system
stellar magnitude
supernova
variable star
white dwarf
zodiac

**see next page for word search definitions*

SPACE KEY WORD DEFINITIONS

VISIT THESE SITES FOR MORE ASTRONOMY VOCABULARY BUILDERS

<https://www.sciencekids.co.nz/sciencefacts/space/definitions.html>

ASTERISM - easily recognized pattern of stars, from one or more constellations.

ASTEROID - small, rocky object in the Solar System, not a satellite of a planet; most asteroids are located in the Asteroid Belt between the orbits of Mars and Jupiter.

ASTRONAUT - space traveller.

BLACK HOLE - enormously dense object with gravity so great that nothing can escape, including light; formed from the collapse of a super-massive star.

CELESTIAL SPHERE - system of mapping the space around the Earth; an imaginary sphere surrounding Earth.

CIRCUMPOLAR - circling the pole star (Polaris).

COMET - chunk of dirty, dark ice mixed with dust, rocks, and gases which revolves around the Sun in an elliptical orbit; emits volatiles (gases) in a long "tail" as it nears the Sun and heats up.

CONSTELLATION - defined area of the sky containing a star pattern, agreed upon by the scientific community.

ECLIPTIC - the Sun's apparent annual path across the celestial sphere as observed from Earth; same path is also approximately followed by the moon and planets.

EXOPLANET - planet orbiting a star other than the Sun; hundreds have been discovered in the last decade.

GALAXY - huge group of stars, gas, and dust that may contain millions to hundreds of billions of stars held together by gravity.

GLOBULAR CLUSTER - immense sphere-shaped, relatively compact, gravity-linked group of hundreds of thousands or even millions of stars; looks like a fuzzy patch in the night sky.

GRAVITY - the force of attraction that pulls a smaller object toward a more massive object.

LIGHTYEAR - the distance light travels in a year, 9.6 trillion km.

LUNAR ECLIPSE - the Moon moves into Earth's shadow as Earth passes between Sun and Moon.

METEOR - bright streak of light seen as a meteoroid burns up entering the Earth's atmosphere (moving up to 500 km/sec!).

METEORITE - meteoroids that do not burn up completely and land on Earth.

METEOROID - small rocky and/or metallic fragment orbiting the Sun - varying in size from a grain of sand to less than a kilometer across.

NEBULA - vast cloud of gas and dust in space where new stars may form.

NEUTRON STAR - small, dense star resulting from the collapse of a super-giant star.

OPEN CLUSTER - irregular-shaped star group consisting of a few dozen to several thousand relatively young stars bound by gravity.

ORBIT - the path of one object as it revolves around another.

PLANET - large spherical object that revolves around a star and dominates its orbital path.

PULSAR - rotating neutron star that gives off short, sharp pulses of radio waves.

QUASAR - most luminous object in the universe powered by supermassive black holes; radiation is emitted into space as material falls into a black hole, usually at the center of a galaxy - this is referred to as an AGN - Active Galactic Nucleus; extremely far away.

RED GIANT - type of star that has a relatively low temperature and is many times larger than the Sun; forms as a star uses up fuel.

RED SHIFT - the measurable change in the wavelength of light as an object in space moves away from our point of view.

ROTATION - the spinning of an object on its axis.

SATELLITE - an object orbiting around another object held by gravity.

SOLAR ECLIPSE - total or partial blocking of the Sun by the Moon; the Moon passes between Sun and Earth.

SOLAR SYSTEM - the Sun and everything that orbits it.

STELLAR MAGNITUDE - the brightness of a star or other heavenly body.

SUPERNOVA - explosive death of a massive star (at least 8 times the mass of the Sun); expels elements into space.

VARIABLE STAR - a type of star whose brightness changes over time, usually in a predictable way.

WHITE DWARF - small hot star no longer producing nuclear fusion.

ZODIAC - the thirteen constellations along the ecliptic through which the Sun and planets appear to travel during the course of a year.

BOOKS

Mission Control, This is Apollo, by Andrew Chaikin and Alan Bean. New York: Viking Juvenile, 2009. Ages 8-13. Description of all Apollo missions from the astronauts' point of view. Drawings are by Astronaut Alan Bean.

Beyond: A Solar System Voyage, by Michael Benson. New York: Harry N. Abrams, 2009. Ages 8-14. Beautiful photographs; simple, informative text.

Space Encyclopedia: A Tour of Our Solar System and Beyond (National Geographic Kids), by David A. Aguilar. Washington, DC: National Geographic Children's Books, 2013. Ages 10 and up.

Nightwatch: A Practical Guide to Viewing the Universe, by Terrence Dickenson, Adolf Schaller, and Timothy Ferris. Ontario: Firefly Books, 2014. Considered the best general interest introduction to astronomy; also the top-selling stargazing guide. Updated through 2025.

WEBSITES

Astronomical Society of the Pacific: Inspiring people to look up and wonder for 125 years, the ASP's mission is to increase the understanding and appreciation of astronomy and to advance science and science literacy. www.astrosociety.org

NASA Solar System: National Aeronautics and Space Administration's best and most up-to date sites for all things Solar System, including information about moons, planets, and space missions. <https://science.nasa.gov/solar-system/>

NASA for Kids: An interactive site including a homework helper, games, planets and DIY projects. <https://science.nasa.gov/kids/>

NASA Jet Propulsion Laboratory (JPL): Teachers will appreciate this site for its space science lessons. <https://www.jpl.nasa.gov/edu/>

NASA Planetary Photojournal: New images released from spacecraft missions. <https://photojournal.jpl.nasa.gov/>

Cassini Mission to Saturn: JPL's main site for Cassini spacecraft, the most recent pictures of Saturn and its moons. <https://science.nasa.gov/mission/cassini/>

The Visible Earth: NASA collection of amazing images of our home planet. <https://visibleearth.nasa.gov/>

Kennedy Space Center: Explore Kennedy Space Center Visitor Complex in a completely new way with a virtual tour. <https://www.kennedyspacecenter.com/>

Hubble Heritage: The best locations for HST images and beautiful pictures in the gallery. <https://hubblesite.org/images/hubble-heritage>

The Scale of the Universe: A great place to explore scale of the universe, from the universe to the atom and smaller. <https://scaleofuniverse.com/en>

Zooniverse: Participate in Citizen Science: crowd-sourcing for MANY space-related research projects. Discover new planets, map the moon and Mars; study the sun or black holes. <https://www.zooniverse.org/>

Pisgah Astronomical Research Institute (PARI): PARI offers a variety of programs for students of all ages, including the StarLab Planetarium and the Space Science Lab. <https://www.pari.edu/visit/>

Sky Charts: Free printable evening sky maps available for northern and southern hemispheres. <https://skymaps.com/>

FAQS ABOUT THE FILM

Students' questions about *IN SATURN'S RINGS* can lead to many other subjects—science, history, art, music, film-making, and so on. We invite you to open a dialogue after viewing the film. Here is a list of frequently asked questions to prompt your discussions.

Q: Why do Saturn's rings look “cut off” in the film?

A: In space, shadows without air are totally black vs. those on Earth, where air scatters light. Also, sometimes Cassini takes photos from odd angles where the eye does not realize it's seeing a shadow, since the space next to the shadow is black too.

Q: Why does the Sun look white in the film?

A: The Sun actually IS white – technically, a very light magenta that would look white to the human eye in space. It's shown as yellow-orange elsewhere because many scientists typically add the color to photos – they believe people expect to see it that color, since it looks that way through most solar filters at sunrise/sunset due to pollution. *Note: it is unsafe to look at the Sun without proper filters.*

Q: Why are there so many stars in the time-lapse section of the film?

A: Far more stars are in the sky than we usually see – *IN SATURN'S RINGS* just lets us see them. On Earth, light pollution typically hides most stars. If you were out in space, you would see 2000 to 3000 stars vs. the 20 to 30 you would see in most major cities in the world. Beyond that, the photos in the time-lapse are long exposure with light-sensitive cameras, and so can pick up more light than your eye can.

Q: How can you show pictures from back in time in the film – isn't that CGI?

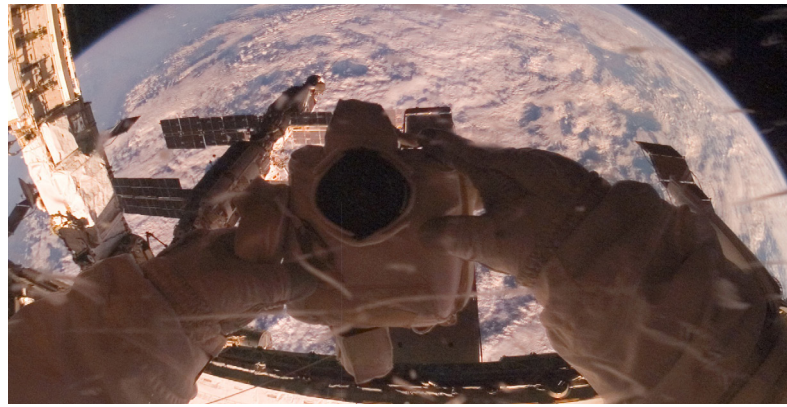
A: No, it's not CGI. It takes time for light from an object to travel to our eyes. As a result, the more distant the object, the further back in time the light comes from. Because the objects a telescope sees are so far away, we can see objects as they were 13 billion years ago and more.

Q: Is the moon black and white or is it dusty brown?

A: The moon is mostly grey with a bit of brown tint, depending on geology of the area. For the film, we used photos from the LRO (Lunar Reconnaissance Orbiter), which has black and white cameras; as well as Apollo and ground-based telescopes – which have color cameras.

Q: Is this exactly what the spacecraft sees?

A: Sometimes – but many sections like Cassini are photo animations of large mosaics of Cassini photographs, as Cassini only has a 1 megapixel black and white camera (but with many special filters). Everything has to be assembled on Earth from several photographs, like the “Panorama” feature on your camera or smartphone camera. Like that feature, it may not be what those cameras see, but is a close facsimile of what your eyes would see.



© 2014 NASA. ISS Earth astronaut's helmet.

ABOUT THE FILMMAKER

Filmmaker Stephen V. Stone first learned of Saturn and Titan as a child, viewing Carl Sagan's *Cosmos*. Then, in 2004, the Cassini spacecraft arrived at Saturn, barely noticed by the world. Captivated by the stunning images from the mission and disappointed by the lack of public interest, Stephen committed himself to finding a way to showcase the incredible beauty of Saturn and our entire universe. After years of dedicated research and experimentation, Stephen was able to bring Cassini's still photos to life.

The incredible journey of *IN SATURN'S RINGS* is the result of producer Stephen Stone's pioneering dedication and a devoted team of more than 50 volunteers, scientists, photographers, and astronomers from around the world.

NEXT GENERATION SCIENCE STANDARDS (NGSS)	Take a Solar System Walk	Saturn by Numbers	Make Your Own Craters	Pixel This!	What is Light Pollution?	Space Key Word Definitions
Earth and Space Science ESS						
ESS1A The Universe and Its Stars					x	x
ESS1B Earth and the Solar System	x	x	x	x		x
ESS1C The History of Planet Earth			x			
ESS3C Human Impacts on Earth Systems					x	
Engineering, Technology and Applications of Science ETS						
ETS1A Defining and Delimiting an Engineering Problem				x	x	
ETS1B Developing Possible Solutions					x	
ETS1C Optimizing the Design Solution				x	x	
Physical Science PS						
PS2A Forces and Motions			x			
PS3B Conservation of Energy and Energy Transfer			x			
PS4C Information Technologies and Instrumentation				x		

* For more details, Social Studies and Science standards, please refer to your local State Standards. For more information please visit www.nextgenscience.org

CREDITS AND ACKNOWLEDGEMENTS

EDUCATOR GUIDE TEAM

Activity Developers, Co-Writers and Teaching Consultants: Andrew Chaikin, Kathleen Dusto, Tim Martin, Kevin McAbee, Tony Rice

Additional Consultants on Educator Guide:

Dr. Michael J. Malaska, Senior Postdoctoral Fellow at Jet Propulsion Laboratory/California Institute of Technology & Dr. Morgan Cable, Research Scientist at JPL/Caltech

Graphic Design, Project Manager:
Marie Stone van Vuuren

Editor, Co-Writer, Co-Designer: Jane Gwyn Ward

Assistant Editors: Portia McCracken, Marie Stone van Vuuren, Jacqueline Pierce Messick, Michael Artman

Content & Standards Research: Tim Martin, M.S. and Kathleen Dusto

With thanks to: Rich Hoffman, Erin Martin, Monica Moran and the over 1,000 donors and volunteers who have made this film and Educator Guide possible. Special thanks to NASA/PL/SSI/CiClops for images used in this guide and the film.

Producer & Distributor:

Stephen V. Stone
In Saturn's Rings, LLC
336.202.4777

www.insaturnsrings.com
info@insaturnsrings.com

