

7-12 Planetarium Lesson: How Do We Know?

Theme:

Scientific knowledge is ever evolving. Our solar system, galaxy, and universe can be better understood through observation and the scientific process.

Goals:

- Students will understand that scientific knowledge changes over time.
- Students will understand that scientific advancements, including those in astronomy, depend on curiosity and a broad knowledge base.
- Students will understand the importance of acute observation and will have a desire to observe the sky.
- Students will view UAF as an option for continuing their own education.

Objectives:

- Students will learn that most objects in the sky have apparent motions that are predictable.
- Students will be able to describe how gravitational attraction affects planets and other bodies in orbit.
- Students will know that the universe is expanding.

Alaska Science Performance Standards/Grade Level Expectations:

SA1.1 (7-12): The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating.

SD3.1 [8]: The student demonstrates an understanding of cycles influenced by energy from the sun and by Earth's position and motion in our solar system by recognizing the relationship between the seasons and Earth's tilt relative to the sun and describing the day/night cycle as caused by the rotation of the Earth every 24 hrs.

The student demonstrates an understanding of the theories regarding the origin and evolution of the universe by:

SD4.4 [9]: identifying the Big Bang Theory.

SE3.1 [7]: The student demonstrates an understanding of how scientific discoveries and technological innovations affect our lives and society by recognizing the effects of a past scientific discovery, invention, or scientific breakthrough (e.g., DDT, internal combustion engine).

SG 1.1 [9]: The student demonstrates an understanding of changes in historical perspectives of science by identifying those perspectives (i.e., cultural, political, religious, philosophical) that have impacted the advancement of science.

SG3.1 [11]: The student demonstrates an understanding that scientific knowledge is ongoing and subject to change by investigating instances when scientists' observations were not in accord with prevailing ideas of the time.

SG4.1 [10]: The student will demonstrate an understanding that advancements in science depend on curiosity, creativity, imagination, and a broad knowledge base by recognizing the role of these factors on scientific advancements.

Alaska Content Standards-Cultural Standards:

B2: Students make effective use of the knowledge, skills and ways of knowing from their own cultural traditions to learn about the larger world in which they live.

E4: Students determine how ideas and concept from one knowledge system relate to those derived from other knowledge systems.

Outline:

Outside the Dome

- Introduce yourself. Say you are from Fairbanks & work at the University (UAF).
- Explain a little about the project and why we are at their school today.
- Explain what it will be like inside, how to enter and exit, the rules...etc.

Introduction Inside the Dome

- Introduce yourself and define astronomy.
- Explain a little about how the planetarium works (laptop, projector, fisheye lens).
- Talk about UAF.
 - Mention the GI and Museum and include a little info about visiting campus or being a UAF student.

Observing the Sky

- Start with day sky. Watch sun & discuss how diff. here, why, etc. [sun's path today and path in summer and winter]
- Move to night sky & go over basics of night sky [night sky & const., etc]
- Discuss observers over time
 - Culture bearers (Alaska Native Story)
 - Astronomers
- These observers noticed how things change in the sky and what seems to be constant. Now we have more tools to help us in our observing.
- Apparent movement of sun and stars
- Movement of planets ("wanderers") [planetary movement compared to stars & example of retrograde motion]

'Explaining' It

- Process of hypothesizing and testing (for science)
- Geocentric model [animated solar system in geocentric model]
- Retrograde Motion [example of ret. motion]
- Heliocentric Model [animated solar system in heliocentric model]
 - Society/religious pressures
- Copernicus (early 1500s)
- Kepler
 - Shape of planet's orbit is an ellipse
 - Planets move faster when closer to the sun
- Galileo (1600s)
 - Adv. of tech & knowledge
 - Venus
 - Moons of Jupiter [Obs. Jupiter with moons & Galileo's sketches]
- Newton (late 1600s)
 - Gravity helped clarify Kepler's work
 - Law of gravitation: force attracting 2 objects proportional to mass & inversely proportional to distance from one another

Our place

- Solar system to galaxy.
 - Review of solar system
 - Galaxy: aggregate of gas, dust and stars. Held together by gravitational forces.
 - Milky Way has several hundred billion stars. [Milky Way from space]

- Galaxy to universe.
 - All things in the universe have common origin (Big Bang).
 - We are cosmic debris.
 - Started 10-20 billion years ago. Solar System only ~4.5 billion yrs old.
 - Universe still expanding
- So far we seem unique but there is much to explore and discover! [back to Earth]

Starry Night Script:

HOW DO WE KNOW? (7-12)

Put the Computer into [RED SCREEN MODE](#) to help you & students see better in the planetarium.

Put the [UAF Logo](#) on the screen before you get into the show.

Introduction

Introduce yourself and define **astronomy**: the study of the universe and the celestial bodies residing in it, including their composition, history, location, and motion.

Explain a little about how the planetarium works (laptop connected to a projector with a fisheye lens).

Talk about **UAF**. Mention the Geophysical Institute and Museum and include a little information about visiting campus or becoming a UAF student. ([Click HERE](#) to remove the UAF logo.)

Observing the Sky

Begin with a **daytime view** of an Alaskan sky from Fairbanks or preferably from your current location (*Push apple-L to change location*). Ask what they see and then discuss what they already know about the sun's path in the sky and how our view differs from more southern locations on the globe.

[SPEED UP TIME \(3000x\)](#) and **watch the sun set**. Review why the sun appears to rise and set: because the earth is rotating on its axis every 24 hours. ([STOP TIME](#)) *Contrast briefly with length of year & that this is because of orbit, not rotation. Review term **orbit** and **rotation**.*

Once you have a **dark sky**, you may want to make it artificially dark to enhance star viewing. [TURN OFF DAYLIGHT](#)

Go over some of the **basics of the Alaskan night sky**. Explain how to describe locations of objects in the sky' by using the compass **directions, horizon, zenith** and degrees. Then, point out the big dipper (Ursa Major) and the north star.

[TRACE BIG DIPPER](#)
[TRACE URSA MAJOR](#)
[LABEL POLARIS](#)

If you wish to deselect the big dipper, etc: push apple-Y

People have been watching stars and observing the sky for a very long time, even before sophisticated tools like the telescope. Through observation, looking up!, they learned to recognize patterns in the stars like these. They also learned how to recognize changes and predictable movements. Their explanations of these movements and the stories coming from different cultures varied. However, they all noticed how things change in the sky and what seems to be constant.

So what do we know about movements in the sky? What happens to these stars if we advance time?

[TURN OFF SATELLITES](#) and then [RUN TIME FORWARD \(3000x\)](#) and **watch the big dipper and Polaris.** [\(STOP TIME\)](#)

Just like the apparent rise and set of the sun, the stars appear to rotate throughout the night because of the earth's **rotation** on its axis. So, movements can be observed in one night.
Emphasize rotation on axis.

Big Dipper Story:

In circumpolar regions around the world, people have identified the Big Dipper with a type of deer; usually a caribou or reindeer. Inupiaq, Yup'ik, and Aleut people in Alaska have regarded the stars of the dipper as resembling one or more caribou. Koyukon Athabascans in interior Alaska have also regarded the Big Dipper as a deer, but instead of a caribou they notice a moose, which is also a member of the deer family.

Across the Bering Sea in Russia, a group of people called the Chukchi who have a long tradition of reindeer herding have a story about the well known reindeer in the sky. The Chukchi say the reindeer is tethered to a post or nail star (Alq'pe'near). If you observe the sky, the reindeer can be seen throughout the night pacing a great circle around the star to which it is tethered. [CARIBOU VIDEO](#) What star do you think they call the "nail star"?

Stars are also a source of **stories from all around the world.** [TURN ON THE CONSTELLATION ILLUSTRATIONS.](#) Culture bearers know these tales that translate history and traditions. The ones pictured here come from the Greeks and Romans and are now known by astronomers all around the world.
[TURN OFF THE CONSTELLATION ILLUSTRATIONS.](#))

Pleiades Story:

Even though most of us only know the common Greek/Roman constellations, people throughout the world have different names for constellations unique to their own culture.

Point out the **Pleiades** and ask the students if they know a name for this group of stars?

The Pleiades is a group of hot, bright stars that form the brightest star cluster visible in the sky. Another name for the star cluster is the **seven sisters**, or **Subaru**, after which the Japanese car company named themselves.

Coastal cultures across Alaska also have their own name for this group of stars. [Pleiades Movie](#)

Throughout the **Aleutian Islands** the Pleiades are known as a **bundle of codfish** (Atxidan Tamingin). In southeast Alaska, the **Tlingit** know the Pleiades as an **old sculpin fish** (Weq). Alaska's well known creator and trickster, the Raven, gave the sculpin a special place in the sky after discovering that the fish was older than he.

In **northern Alaska**, the Pleiades are visualized as a scene from a **polar bear hunt**. Some Inupiaq call the star cluster Pa-chuk-turin, which means the sharing or dividing. The largest star is viewed as the polar bear, and the others around it are the hunters who are dividing and sharing the meat from their successful hunt.

The Inupiaq have also been known to use the Pleiades as a timepiece, or **sky clock**. In times of old, the Pleiades marked bedtime for the Kobuk River Eskimos when it reached a certain position in the sky. They called the stars Sakopsaktat, which means "the ones who close their eyes."

The Pleiades has also been used as a **timepiece** among the **Alutiiq of Kodiak Island** where the star cluster marks the beginning of the New Year when it is first seen above the horizon in early August.

Yup'ik Eskimos along the Bering Strait have known the Pleiades as a **litter of fox pups**, while those around **Norton Sound** and the **Lower Yukon River** have regarded the Pleiades as a single **red fox** (Kagguyat or Kavyagak).

The **Haida** in the far southeast part of Alaska call the stars of the Pleiades a **water bailer**, which is used to scoop water out of their canoes. The name for this is Hoot-oo.

The stars in the Pleiades are hard to miss despite the small space they occupy in the night sky (together, they kind of look like a short-handled little dipper). They shine so bright and vivid that cultures the world over have adopted them into their culture. Try to imagine some of the age old shapes and stories given to the Pleiades the next time you look up at the stars over Alaska.

Astronomers are much like other sky observers. Astronomers also **observe** change and constancy in the sky and try to explain it. We now have more tools to help us in our observing, such as telescopes and spacecraft. However, the basic knowledge serves as the foundation for discovery.

Movements can be observed in one night. However, watching over the course of many nights, one notices other changes in the sky.

Here is a [VIEW OF THE MOON](#) on September 1, 2009.

Using the same moon view, [TURN OFF SATELLITES](#) and [PLAY TIME FORWARD](#). Ask the students what else they see moving besides the moon.

Keen observers noticed something else changing in the sky that was more subtle than the moon. They noticed that some of these "stars" did not stay in their place from night to night. Some of them seemed to "wander." This is how the existence of other planets was discovered. The word **planet means "wanderer."** You can see the sun, moon and planets traveling along the path of the ecliptic in this view. Notice how they sometimes appear to go "backwards."

Give an example of retrograde motion (i.e..passing a car) [RETROGRADE MOTION VIDEO](#)

The slower moving planets beyond earths orbit appear to move backwards because the faster moving earth passes them (though all the planets are actually moving forward in orbit around the same common point, the sun)

'Explaining' It

As a scientist, astronomers need to ask questions, hypothesize an answer and test it. One of the first models of the solar system put the earth at the center and the planets and sun in orbit around us. If the earth was standing still, with things orbiting us, some things would make sense. The sun and stars rise/set would look the same. However, explaining the planetary movements is a bit more complicated.

This model is called the [GEOCENTRIC MODEL](#). "Geo" for earth and "centric" for middle. Press the **play** arrow to watch the paths of the planets in this model. *You may have to zoom out a little.*

This is not a very simple model. While the sun makes a nice orbit around the earth in the model, the movements of the planets as observed from earth are hard to incorporate without some complicated planetary paths. Remember how the planets sometimes appear to move backwards? The geocentric model couldn't account for this motion, called **retrograde motion** well.

By moving the sun to the center with the planets and the earth in orbit around it, things were much clearer.

[HELIOCENTRIC MODEL](#).

Since the earth is also in motion, we sometimes "catch up" with other planets in orbit. As we pass them, they appear to go backwards. The heliocentric, or sun centered, model deals with this well. *Ask again: define orbit*

Copernicus presented this model in the **1500s** and his model also had the earth rotating once a day. It took almost 100 years for astronomers to accept this model.

Partially, it was hard to accept because of cultural and religious pressures. The earth was to be the center of things!

Another part of the problem with Copernicus' model was that the planet's orbits were circular and this caused problems for predicting where planets would be seen. The shape of a planet's orbit is actually an ellipse. In the **1600s Kepler** corrected Copernicus' model and changed the **orbits to ellipses**. Galileo further solidified evidence for the model when he observed the moons of Jupiter. Showing that objects orbit other planets (not just Earth) supported the idea that not everything was in orbit around us.

If time allows:

See [JUPITER'S MOONS](#) as you would through a telescope and as Galileo did. Zoom out manually to see all the moons (Galilean satellites). Zoom out to at least 22'x22'. This will allow you to view Callisto's full path. **Advance time** to see the Galilean satellites movement.

Our place

The solar system is "our home" and we now understand quite a lot about it. Here is a view of our solar system.

[OUTER SOLAR SYSTEM](#)

What is missing here? (Mercury, Venus, Earth and Mars). This is a view of the outer planets (the gas giants). Notice how eccentric Pluto's orbit is. Pluto is no longer considered a planet, but rather is a dwarf planet.

Discuss the **speed of the planets in orbit** and how those closer to the sun move faster (Kepler's law). **Zoom** in to see the inner planets. You will simply see dots whizzing around the sun!

Show a view of the [INNER SOLAR SYSTEM](#). (*You will probably need to zoom out!*) These are the terrestrial planets and the asteroid belt. *Ask what keeps planets in orbit around the sun (gravitational forces).*

Our solar system is just a small part of our galaxy, the Milky Way.
Show the [MILKY WAY FROM SPACE](#). (*or use Fav/Stars/Sun in Milky Way*).

Just as gravitational forces keep planets in orbit around the sun, galaxy's are held together by gravitational forces. A galaxy is an aggregate of gas, dust and stars held together by gravitational forces. The Milky Way contains at least several hundred billion stars.

If you press **play**, you can travel around the Milky Way.

Moving out even further, our galaxy is part of the universe. [LOCAL UNIVERSE](#)

There is still much to learn about our universe. One thing we do know is that while gravitational attraction pulls some bodies closer together, the universe as a whole is expanding. This expansion started when the universe started. Our solar system is ~4.5 billion years old. However, our universe is 10-20 billion years old!

Most astronomers agree that our universe started in the "Big Bang." The Big Bang occurred at a time when there was no space and no time. All we had was energy in a point smaller than a grain of rice. The Big Bang was not an explosion in the universe, it was an explosion of the universe! The universe rapidly expanded. Eventually, particles began to coalesce and gravity pulled galaxies together.

[BIG BANG ANIMATION \(large\)](#)

The universe is still expanding! We have learned a lot about our universe, but there is still a lot to explore and discover, and new space is created every day!

Go back to Earth

Go to the Favourites Menu: Solar System/Earth and select "Our Home" for a view of the Earth in space.
