ECLIPSES DETAILS

- **Eclipses in mythology and religion:**

Before eclipses were understood as well as they are today, there was a much more fearful connotation surrounding the seemingly inexplicable events. There was very considerable confusion regarding eclipses before the 17th century because eclipses were not very accurately or scientifically described until Johannes Kepler provided a scientific explanation for eclipses in the early seventeenth century.

Typically in mythology, eclipses were understood to be one variation or another of a spiritual battle between the sun and evil forces or spirits of darkness. The phenomenon of the sun seeming to disappear was a very fearful sight to all who did not understand the science of eclipses as well as those who supported and believed in the idea of mythological gods. The sun was highly regarded as divine by many old religions, and some even viewed eclipses as the sun god being overwhelmed by evil spirits. More specifically, in Norse mythology, it is believed that there is a wolf by the name of Fenrir that is in constant pursuit of the sun, and eclipses are thought to occur when the wolf successfully devours the divine sun. Other Norse tribes believe that there are two wolves by the names of Sköll and Hati that are in pursuit of the sun and the moon, known by the names of Sol and Mani, and these tribes believe that an eclipse occurs when one of the wolves successfully eats either the sun or the moon. Once again, this mythical explanation was a very common source of fear for the majority of people at the time who believed the sun to be a sort of divine power or god because the known explanations of eclipses were quite frequently viewed as the downfall of their highly regarded god. Similarly, other mythological explanations of eclipses describe the phenomenon of darkness covering the sky during the day as a war between the gods of the sun and the moon.

In most types of mythologies and certain religions, eclipses were seen as a sign that the gods were angry and that danger was soon to come, so people often altered their actions in an effort to dissuade the gods from unleashing their wrath. In the Hindu religion, for example, people often sing religious hymns for protection from the evil spirits of the eclipse, and many people of the Hindu religion refuse to eat during an eclipse to avoid the effects of the evil spirits. Hindu people living in India will also wash off in the Ganges River, which is believed to be spiritually cleansing, directly following an eclipse to clean themselves of the evil spirits. In early Judaism and Christianity, eclipses were viewed as signs from God, and some eclipses were seen as a display of God's greatness or even signs of cycles of life and death. However, more ominous eclipses such as a blood moon were believed to be a divine sign that God would soon destroy their enemies.

- **How do Eclipses occur?**

*An **eclipse** is an astronomical event that occurs when an astronomical object or spacecraft is temporarily obscured, by passing into the shadow of another body or by having another body pass between it and the viewer. This alignment of three celestial objects is known as a syzygy(A word from ancient Greek and is often used in reference to the Sun, Earth, and either the Moon or a planet). An eclipse is the result of either an occultation (completely hidden) or a transit (partially hidden).*

- **Types of Eclipses?**

  - **Solar Eclipse:** *A **solar eclipse** occurs when the Moon passes between Earth and the Sun, thereby obscuring the view of the Sun from a small part of the Earth, totally or partially. Such an alignment occurs approximately every six months, during the eclipse season in its new moon phase, when the Moon's orbital plane is closest to the plane of the Earth's orbit. In a total eclipse, the disk of the Sun is fully obscured by the Moon. In partial and annular eclipses, only part of the Sun is obscured. Unlike a lunar eclipse, which may be viewed from anywhere on the night side of Earth, a solar eclipse can only be viewed from a relatively small area of the world. As such, although total solar eclipses occur somewhere on Earth every 18 months on average, they recur at any given place only once every 360 to 410 years. If the Moon were in a perfectly circular orbit and in the same orbital plane as Earth, there would be total solar eclipses once a month, at every new moon. Instead, because the Moon's orbit is tilted at about 5 degrees to Earth's orbit, its shadow usually misses Earth. Solar (and lunar) eclipses therefore happen only during eclipse seasons, resulting in at least two, and up to five, solar eclipses each year, no more than two of which can be total. Total eclipses are more rare because they require a more precise alignment between the centers of the Sun and Moon, and because the Moon's apparent size in the sky is sometimes too small to fully cover the Sun.*

- **Types:**

  *- A **total eclipse** occurs when the dark silhouette of the Moon completely obscures the intensely bright light of the Sun, allowing the much fainter solar corona to be visible. During any one eclipse, totality occurs at best only in a narrow track on the surface of Earth. This narrow track is called the path of totality.*

  *- An **annular eclipse** occurs when the Sun and Moon are exactly in line with the Earth, but the apparent size of the Moon is smaller than that of the Sun. Hence the Sun appears as a very bright ring, or annulus, surrounding the dark disk of the Moon.*

  *- A **hybrid eclipse** (also called **annular/total eclipse**) shifts between a total and annular eclipse. At certain points on the surface of Earth, it appears as a total eclipse, whereas at other points it appears as annular. Hybrid eclipses are comparatively rare.*

  *- A **partial eclipse** occurs when the Sun and Moon are not exactly in line with the Earth and the Moon only partially obscures the Sun. This phenomenon can usually be seen from a large part of the Earth outside of the track of an annular or total eclipse. However, some eclipses can be seen only as a partial eclipse, because the umbra passes above the Earth's polar regions and never intersects the Earth's surface. Partial eclipses are virtually unnoticeable in terms of the Sun's brightness, as it takes well over 90% coverage to notice any darkening at all. Even at 99%, it would be no darker than civil twilight.*

- **Lunar Eclipse:** *A **lunar eclipse** is an astronomical event that occurs when the Moon moves into the Earth's shadow, causing the Moon to be darkened. Such alignment occurs during an eclipse season, approximately every six months, during the full moon phase, when the Moon's orbital plane is closest to the plane of the Earth's orbit. This can occur only when the Sun, Earth, and Moon are exactly or very closely aligned with Earth between the other two, which can happen only on the night of a full moon when the Moon is near either lunar node. The type and length of a lunar eclipse depend on the Moon's proximity to the lunar node. When the Moon is totally eclipsed by the Earth, it takes on a reddish color that is caused by the planet when it completely blocks direct sunlight from reaching the Moon's surface, as only the light reflected from the lunar surface has been refracted by the Earth's atmosphere. This light appears reddish due to the Rayleigh scattering of blue light, the same reason sunrises and sunsets are more orange than during the day. Unlike a solar eclipse, which can only be viewed from a relatively small area of the world, a lunar eclipse may be viewed from anywhere on the night side of Earth. A total lunar eclipse can last up to nearly two hours, while a total solar eclipse lasts only a few minutes at any given place, because the Moon's shadow is smaller.*

  - **Types:** *Earth's shadow can be divided into two distinctive parts: the umbra and penumbra. Earth totally occludes direct solar radiation within the umbra, the central region of the shadow. However, since the Sun's diameter appears to be about one-quarter of Earth's in the lunar sky, the planet only partially blocks direct sunlight within the penumbra, the outer portion of the shadow.*

    - The **umbra** (Latin for "shadow") is the innermost and darkest part of a shadow, where the light source is completely blocked by the occluding body. An observer within the umbra experiences a total occultation. The umbra of a round body occluding a round light source forms a right circular cone. When viewed from the cone's apex, the two bodies appear the same size.
    - The **penumbra** (from the Latin *paene* "almost, nearly") is the region in which only a portion of the light source is obscured by the occluding body. An observer in the penumbra experiences a partial eclipse. An alternative definition is that the penumbra is the region where *some or all* of the light source is obscured (i.e., the umbra is a subset of the penumbra).

      *- **penumbral lunar eclipse**: occurs when part or all of the Moon passes into the Earth's penumbra. No part of the moon is in the Earth's umbra during this event. The penumbra causes a subtle dimming of the lunar surface, which is only visible to the naked eye when about 70% of the Moon's diameter has immersed into Earth's penumbra. A special type of penumbral eclipse is a total penumbral lunar eclipse, during which the entire Moon lies exclusively within Earth's penumbra. Total penumbral eclipses are rare, and when these occur, the portion of the Moon closest to the umbra may appear slightly darker than the rest of the lunar disk.*

- partial lunar eclipse*: When the Moon penetrates partially into the Earth's umbra, it is known as a partial lunar eclipse, During this event, one part of the moon is in the Earth's umbra, while the other part is in the Earth's penumbra.The Moon's average orbital speed is about 1.03 km/s (2,300 mph), or a little more than its diameter per hour, so totality may last up to nearly 107 minutes. Nevertheless, the total time between the first and last contacts of the Moon's limb with Earth's shadow is much longer and could last up to 236 minutes.*

-Total lunar eclipse: *If the Moon entirely passes into the Earth's umbra, a total lunar eclipse occurs. Just prior to complete entry, the brightness of the lunar limb—the curved edge of the Moon still being hit by direct sunlight—will cause the rest of the Moon to appear comparatively dim. The moment the Moon enters a complete eclipse, the entire surface will become more or less uniformly bright. Later, as the Moon's opposite limb is struck by sunlight, the overall disk will again become obscured. This is because, as viewed from the Earth, the brightness of a lunar limb is generally greater than that of the rest of the surface due to reflections from the many surface irregularities within the limb: sunlight striking these irregularities is always reflected back in greater quantities than that striking more central parts, which is why the edges of full moons generally appear brighter than the rest of the lunar surface. This is similar to the effect of velvet fabric over a convex curved surface, which, to an observer, will appear darkest at the center of the curve. It will be true of any planetary body with little or no atmosphere and an irregular cratered surface (e.g., Mercury) when viewed opposite the Sun.*

- Central lunar eclipse*: is a total lunar eclipse during which the Moon passes through the centre of Earth's shadow, contacting the antisolar point. This type of lunar eclipse is relatively rare.The relative distance of the Moon from Earth at the time of an eclipse can affect the eclipse's duration. In particular, when the Moon is near apogee, the farthest point from Earth in its orbit, its orbital speed is the slowest. The diameter of Earth's umbra does not decrease appreciably within the changes in the Moon's orbital distance. Thus, the concurrence of a totally eclipsed Moon near apogee will lengthen the duration of totality.*

- A selenelion or selenehelion*: also called a horizontal eclipse, occurs where and when both the Sun and an eclipsed Moon can be observed at the same time. The event can only be observed just before sunset or just after sunrise, when both bodies will appear just above opposite horizons at nearly opposite points in the sky. A selenelion occurs during every total lunar eclipse ,it is an experience of the observer, not a planetary event separate from the lunar eclipse itself. Typically, observers on Earth located on high mountain ridges undergoing false sunrise or false sunset at the same moment of a total lunar eclipse will be able to experience it. Although during selenelion the Moon is completely within the Earth's umbra, both it and the Sun can be observed in the sky because atmospheric refraction causes each body to appear higher (i.e., more central) in the sky than its true geometric planetary position.*

- ## Eclipse Season :

  *An **eclipse season** is a period, roughly every six months, when eclipses occur. Eclipse seasons are the result of the axial parallelism of the Moon's orbital plane (tilted five degrees to the Earth's orbital plane), just as Earth's weather seasons are the result of the axial parallelism of Earth's tilted axis as it orbits around the Sun. During the season, the "lunar nodes" – the line where the Moon's orbital plane intersects with the Earth's orbital plane – align with the Sun and Earth, such that a solar eclipse is formed during the new moon phase and a lunar eclipse is formed during the full moon phase. Only two (or occasionally three) eclipse seasons occur during each year, and each season lasts about 35 days and repeats just short of six months later, thus two full eclipse seasons always occur each year. Either two or three eclipses happen each eclipse season. During the eclipse season, the Moon is at a low ecliptic latitude (less than around 1.5° north or south), hence the Sun, Moon, and Earth become aligned straightly enough for an eclipse to occur. Eclipse seasons should occur 38 times within a saros period (6,585.3 days). If both orbits were coplanar (i.e. on the same plane) with each other, then two eclipses would happen every lunar month (29.53 days), assuming the Earth had a perfectly circular orbit centered around the Sun, and the Moon's orbit was also perfectly circular and centered around the Earth. A lunar eclipse would occur at every full moon, a solar eclipse every new moon, and all solar eclipses would be the same type.*

- ## Why do only some people on Earth see an eclipse at a given time?

The visibility of an eclipse from a specific location on Earth depends on several factors, including the alignment of celestial bodies and the observer's geographical position. Here's a detailed explanation of why only some people on Earth see an eclipse at a given time:

1. Alignment of Celestial Bodies:

- Solar Eclipses: For a solar eclipse to occur, the Moon must pass directly between the Sun and the Earth. However, the shadow cast by the Moon during a solar eclipse is relatively small in size and creates a narrow path on the Earth's surface. This path, known as the path of totality, is where the total eclipse is visible.

- Lunar Eclipses: During a lunar eclipse, the Earth is positioned between the Sun and the Moon, causing the Earth's shadow to fall on the Moon. Similar to solar eclipses, the shadow cast by the Earth creates a cone-shaped region in space. However, unlike solar eclipses, lunar eclipses are visible from the nighttime side of the Earth, where the Moon is above the horizon.

2. Geographical Position of the Observer:

- Solar Eclipses: To observe a solar eclipse, an observer must be within the path of totality. The path of totality is relatively narrow, typically ranging from a few kilometers to around 250 kilometers (155 miles) in width. Outside this path, observers will see a partial eclipse or no eclipse at all.

- Lunar Eclipses: The visibility of a lunar eclipse depends on the observer's location on Earth during the time of the eclipse. Lunar eclipses are visible from the regions of the Earth where the Moon is above the horizon during the eclipse. Therefore, if the Moon is below the horizon for a particular geographic location, people in that region will not be able to see the eclipse.

3. Timing and Duration:

- Eclipses have specific timings and durations. The duration of a solar eclipse, including the period of totality, can range from a few minutes to a few hours. The timing of the eclipse is determined by the positions and motions of the Sun, Moon, and Earth.

- Lunar eclipses are generally longer in duration compared to solar eclipses. The entire process of a lunar eclipse, from the start of the partial eclipse to the end, can last several hours.

In summary, the visibility of an eclipse depends on the alignment of celestial bodies, the specific path of the eclipse's shadow, and the observer's geographical position. Eclipses are localized events that can be seen only from certain regions of the Earth, and even within those regions, the visibility of the eclipse may vary. Predictive models and astronomical calculations allow astronomers to determine the exact path and timing of upcoming eclipses, enabling individuals to plan their observations and travel to locations where the eclipse will be visible.

- **What causes the Sun, Moon, and Earth to align ?**

  Solar and lunar eclipses occur due to the alignment of the Sun, Moon, and Earth. The specific alignment depends on the orbits and motions of these celestial bodies. Here's a detailed explanation of what causes the Sun, Moon, and Earth to align during eclipses:

  1. Solar Eclipses:

  - The Moon's Orbit: The Moon orbits the Earth in an elliptical path. However, the Moon's orbit is slightly tilted relative to the Earth's orbit around the Sun. This tilt is approximately 5 degrees. As a result, during most New Moons, the Moon passes either above or below the Sun from our perspective on Earth, and no solar eclipse occurs.

  - Alignment at the Lunar Nodes: For a solar eclipse to occur, the alignment must happen near the points in the Moon's orbit where it crosses the plane of Earth's orbit around the Sun. These points are called the lunar nodes. When the New Moon aligns closely with one of the lunar nodes, a solar eclipse becomes possible.

  - Exact Alignment: During a solar eclipse, the Moon moves between the Earth and the Sun, blocking the Sun's light from reaching certain regions on Earth. The alignment is precise when the Moon is at the right distance from Earth (near perigee, the closest point to Earth in its orbit) and the Sun, Moon, and Earth align in a nearly straight line.

  2. Lunar Eclipses:

  - The Moon's Orbit: Similar to solar eclipses, lunar eclipses occur due to the Moon's orbit around the Earth. The Moon's orbit is again slightly tilted relative to the Earth's orbit around the Sun. This means that during most Full Moons, the Moon passes either above or below the Earth's shadow, and no lunar eclipse occurs.

- Alignment at the Lunar Nodes: For a lunar eclipse to occur, the alignment must happen near the lunar nodes, where the Moon's orbit intersects the ecliptic plane (the plane of Earth's orbit around the Sun).

- Earth's Shadow: During a lunar eclipse, the Earth is positioned between the Sun and the Moon, with the Moon passing through the Earth's shadow. The alignment is precise when the Sun, Earth, and Moon are in a nearly straight line, with the Earth's shadow falling on the Moon.

In summary, the alignment of the Sun, Moon, and Earth during eclipses is a result of the Moon's orbit around the Earth, the tilt of the Moon's orbit relative to the Earth's orbit around the Sun, and the specific positions of the Sun, Moon, and Earth at the time of the eclipse. These alignments allow the Moon to block the Sun's light during a solar eclipse or pass through the Earth's shadow during a lunar eclipse, resulting in these striking celestial events.

- **How do scientists know when and where eclipses will occur?**

Scientists can predict when and where eclipses will occur through a combination of astronomical calculations, observations, and advanced computational models. Here's a detailed explanation of how scientists determine the timing and locations of eclipses:

1. Astronomical Calculations:

- Celestial Mechanics: Scientists use the laws of celestial mechanics, including Kepler's laws of planetary motion, to understand the motion and positions of celestial bodies, such as the Sun, Moon, and Earth. These laws describe the relationships between the orbits, positions, and velocities of these bodies.

- Ephemeris Data: Scientists have precise measurements and models for the positions and motions of celestial bodies. This data includes the positions of the Sun, Moon, and Earth at specific times, which are calculated based on observations and historical data.

- Lunar and Solar Cycles: Scientists study the periodic cycles and patterns related to the Moon's orbit and the alignment of the Sun, Moon, and Earth. These cycles include the synodic month (the time between two consecutive New Moons or Full Moons), the Saros cycle (a period of about 18 years and 11 days after which similar eclipses repeat), and the Metonic cycle (a period of about 19 years after which the phases of the Moon repeat on the same calendar dates).

2. Observations:

- Historical Observations: Scientists have been recording and studying eclipses for centuries. By analyzing historical observations, they can identify patterns, such as the recurrence of similar eclipse events over long periods.

- Astronomical Instruments: Advanced telescopes, cameras, and spectrographs are used to observe and record detailed information about eclipses. These instruments help gather precise data about the positions, shapes, and characteristics of eclipses.

3. Computational Models:

- Numerical Simulations: Scientists use complex computational models and simulations to predict the positions and movements of celestial bodies accurately. These models take various factors into account, such as the gravitational interactions between the Sun, Moon, and Earth, the effects of other celestial bodies, and the precise measurements of their initial conditions.

- Algorithms and Software: Scientists develop algorithms and software programs that incorporate the astronomical calculations and observations. These tools can calculate the positions of celestial bodies at any given time and accurately predict future alignments for eclipses.

4. Collaboration and Resources:

- International Collaboration: Scientists from different countries and organizations collaborate and share data, observations, and computational models. This collaboration increases the accuracy and reliability of eclipse predictions.

- Astronomical Resources: There are dedicated organizations, observatories, and astronomical institutions that specialize in studying and predicting eclipses. These resources compile and disseminate information about upcoming eclipses, including their timing, duration, and visibility from specific locations.

By combining all these factors, scientists can accurately predict when and where eclipses will occur. They can determine the specific dates, times, durations, and geographic regions where solar and lunar eclipses will be visible. These predictions allow astronomers and enthusiasts to plan observations and gather valuable data during these rare and fascinating celestial events.

- **What is an eclipse season and why do they occur approximately every six months (or twice a year)?**

  An eclipse season refers to a period of time, approximately every six months, when solar and lunar eclipses are more likely to occur. During an eclipse season, there can be multiple eclipses, both solar and lunar, within a short span of time. Here's a detailed explanation of what an eclipse season is and why they occur approximately every six months:

  1. Lunar and Solar Nodes:
  - Lunar Nodes: The lunar nodes are the two points where the Moon's orbit intersects the ecliptic plane, which is the plane of Earth's orbit around the Sun. They are known as the ascending node (where the Moon crosses the ecliptic plane from below to above) and the descending node (where the Moon crosses the ecliptic plane from above to below).
  - Solar and Lunar Eclipses: For a solar or lunar eclipse to occur, the alignment of the Sun, Moon, and Earth must happen near these lunar nodes. During a solar eclipse, the Moon aligns between the Sun and Earth (at the new moon phase) near the lunar nodes. During a lunar eclipse, the Earth aligns between the Sun and Moon (at the full moon phase) near the lunar nodes.

  2. Lunar and Solar Orbit Inclinations:
  - Lunar Orbit Tilt: The Moon's orbit around the Earth is inclined by approximately 5 degrees relative to the ecliptic plane (Earth's orbital plane).
  - Solar Orbit Tilt: Similarly, the Earth's orbit around the Sun is inclined by about 7 degrees relative to the ecliptic plane.

  3. Synchronization of Lunar and Solar Orbit Inclinations:
  - Alignment of Lunar and Solar Nodes: The lunar nodes slowly precess (rotate) along the ecliptic plane due to gravitational interactions, taking approximately 18.6 years to complete one full cycle. This precession causes the lunar nodes to move relative to the Earth's orbit around the Sun.
  - Synchronization of Inclinations: Approximately every six months, the alignment of the lunar nodes and the Earth's orbit brings them close to each other. During this period, the Moon's orbit and the Earth's orbit align in such a way that the Sun, Moon, and Earth can come into alignment near the lunar nodes, allowing for the occurrence of eclipses.

  4. Eclipse Season:
  - Increased Probability of Eclipses: When the Moon's orbit and the Earth's orbit align near the lunar nodes, the chances of solar and lunar eclipses increase significantly. This period is referred to as an eclipse season.
  - Multiple Eclipses: During an eclipse season, there can be multiple eclipses within a short time span. For example, there can be a solar eclipse followed by a lunar eclipse or vice versa. The specific number of eclipses during an eclipse season can vary.

  In summary, an eclipse season occurs approximately every six months due to the synchronization of the inclinations of the Moon's orbit and the Earth's orbit, which brings the lunar nodes close to the Earth's orbit. This alignment allows for the occurrence of solar and lunar eclipses near the lunar nodes. The exact timing and number of eclipses during an eclipse season depend on the positions of the lunar nodes and the specific alignment of the Sun, Moon, and Earth.

- **Eye Safety During an Eclipse (Solar Eclipse) :**

  Except during the brief total phase of a total solar eclipse, when the Moon completely blocks the Sun’s bright face, it is not safe to look directly at the Sun without specialized eye protection for solar viewing. Viewing any part of the bright Sun through a camera lens, binoculars, or a telescope without a special-purpose solar filter secured over the front of the optics will instantly cause severe eye injury.

Partial or annular solar eclipses are different from total solar eclipses – there is no period of totality when the Moon completely blocks the Sun's bright face. Therefore, during partial or annular solar eclipses, it is never safe to look directly at the eclipse without proper eye protection.

When watching a partial or annular solar eclipse directly with your eyes, you must look through safe solar viewing glasses ("eclipse glasses") or a safe handheld solar viewer at all times. Eclipse glasses are NOT regular sunglasses; regular sunglasses, no matter how dark, are not safe for viewing the Sun. Safe solar viewers are thousands of times darker.

Always inspect your eclipse glasses or handheld viewer before use; if torn, scratched, or otherwise damaged, discard the device. Always supervise children using solar viewers.

Do NOT look at the Sun through a camera lens, telescope, binoculars, or any other optical device while wearing eclipse glasses or using a handheld solar viewer — the concentrated solar rays will burn through the filter and cause serious eye injury. If you don't have eclipse glasses or a handheld solar viewer, you can use an indirect viewing method, which does not involve looking directly at the Sun. One way is to use a pinhole projector, which has a small opening (for example, a hole punched in an index card) and projects an image of the Sun onto a nearby surface. With the Sun at your back, you can then safely view the projected image.