JAMES WEBB SPACE TELESCOPE

- The James Webb Space Telescope, equipped with a 6.5-meter primary mirror, is a powerful infrared telescope that was launched aboard an Ariane 5 rocket from French Guiana on December 25, 2021.
- Webb is a global partnership involving NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA), with operations managed by the Space Telescope Science Institute following its launch.
- Webb will be the leading observatory of the next decade, exploring all phases of the universe's history—from the initial light after the Big Bang to solar system formation and the evolution of our own Solar System—serving thousands of astronomers globally.
- Webb's key mission includes observing the earliest galaxies and stars post-Big Bang, focusing on how different galaxy types form under varying conditions.
- The telescope will also investigate star formation through dust, utilizing infrared to see hidden processes, and study planet origins and solar system history for clues about life's emergence on Earth.

Technical features:

- Webb is the largest telescope NASA has sent into space.
- It orbits the Sun near the second Sun-Earth Lagrange point (L2).
- Utilizes a combination of primary and secondary mirrors with sophisticated coatings to enhance infrared light collection, achieving unprecedented sensitivity and resolution

  Webb’s Structure:

- **Primary Mirror**:
  - Size: 6.6 meters in diameter.
  - Function: Collects infrared light (0.6—28.8 microns).
  - Structure: Consists of 18 hexagonal segments.
  - Intercepts red and infrared light.
  - Reflects light onto a secondary mirror, which directs it to scientific instruments.

- **Scientific Instruments**:
    - Integrated Science Instrument Module (ISIM) contains:
        - **NIRCam**: Near-Infrared Camera
        - **NIRSpec**: Near-Infrared Spectrograph
        - **MIRI**: Mid-Infrared Instrument
        - **FGS/NIRISS**: Fine Guidance Sensor/Near InfraRed Imager and Slitless Spectrograph
- **Sunshield**: Protects instruments from visible and infrared light from the Sun, Earth, and Moon, providing a cold and thermally stable environment.
- **Detection Capability**: Designed to detect faint red to mid-infrared light from objects as close as Mars to as far as 13.5 billion light-years

1. Uranus: The Ice Giant

Date Captured: 04-06-2023
Distance: 2.8379 billion km

- Zoomed-In Blue Hue Image: Webb captured a detailed view of Uranus, revealing the outer and fainter inner rings, including the Zeta ring.
- A total of 27 known moons of Uranus are also visible in the captured image.
- The image provides a clearer view of the polar cap, which appears as the pole enters direct sunlight in summer and disappears in fall, offering valuable data for scientists to study this unique phenomenon.
- Webb's observations allow for in-depth analysis of Uranus's atmosphere, including its composition and dynamics. Understanding these characteristics enhances our knowledge of ice giants, which are crucial for comparative planetology within our solar system.

Q: How were the images of Uranus likely formed?

A) By the collision of large asteroids with the planet
B) From the gravitational disruption of moons that were pulled apart by tidal forces
C) Through the accumulation of gas and dust from Uranus's atmosphere
D) By the evaporation of icy comets that passed close to the planet

Correct Answer: B) From the gravitational disruption of moons that were pulled apart by tidal forces

2. TRAPPIST-1 B: A World of Possibilities

Date Captured: 03-27-2023
Distance: 39.46 light-years

- Located 40 light-years from Earth, this system contains seven Earth-sized planets orbiting a cool star, with three in the habitable zone raising intriguing possibilities for habitability prospects
- Webb focuses on TRAPPIST-1 b, the closest planet to its star, using thermal emission techniques.
- No significant atmosphere was detected on TRAPPIST-1 b, suggesting it may lack a substantial gaseous envelope and highlighting how stellar features can create misleading signals in atmospheric measurements.
- While a substantial atmosphere is unlikely, thinner atmospheres composed of gases like carbon dioxide or methane cannot be ruled out.

Q: What is the most critical feature to consider when searching for habitable exoplanets?

A) The planet's size and mass, which determine its ability to retain an atmosphere.
B) The presence of an atmosphere that can protect against harmful radiation.
C) The type of star it orbits, particularly if it is stable and long-lived.
D) The planet's location in the habitable zone, where conditions might support liquid water.

Correct Answer: D) The planet's location in the habitable zone, where conditions might support liquid water.

3. WASP-107 b: The "Warm Neptune"

Date Captured: 11-15-2023
Distance: 200 light-years

- WASP-107 b is classified as a "warm Neptune," distinguished by its large radius and low mass, making it one of the least dense planets known.
- Insights from Webb suggest that the exoplanet's core is likely more massive than previously estimated, indicating a complex internal structure.
- The significant internal heating of WASP-107 b may be attributed to tidal forces from its elliptical orbit around its star, contributing to its puffiness.
- Observations reveal various gases in the atmosphere, including water, carbon dioxide, and sulfur dioxide.
- The findings help clarify the planet's formation and internal dynamics, indicating that WASP-107 b shares characteristics with Neptune-like planets rather than having an unusual development.

Question: WASP-107 b is a tidally locked exoplanet. What does it mean for a planet to be tidally locked?

A. It rotates in sync with its orbit, causing one side to be permanently lit and the other in darkness.
B. The gravitational pull between the star and planet varies as the planet orbits.
C. A planet orbiting a small, cool star.
D. A planet with helium in its escaping atmosphere.

Correct Answer: A) It rotates in sync with its orbit, causing one side to be permanently lit and the other in darkness.

4. Chamaeleon I Molecular Cloud: The Birthplace of Stars

Date Captured: 23-01-2023
Distance: 630 light-years

- Located 630 light-years away, this cold, dark region plays a vital role in star and planet formation. It serves as a natural laboratory for studying the early stages of star development.
- Webb has conducted observations that provide an inventory of the icy components within the cloud.
- Scientists have identified a variety of simple and complex molecules, including water, ammonia, and methanol.
- These findings are crucial for understanding the chemical building blocks necessary for the formation of future exoplanets. The presence of these ices suggests the possibility of prebiotic molecules existing in planetary systems.

Q: Findings from the Chamaeleon I Molecular Cloud are crucial for understanding future exoplanet formation, as planets form from circumstellar disks of gas and dust around young stars. Why are these disks, also known as protoplanetary disks, difficult to observe?

A. They only form in cold regions of space, making them rare and hard to find.
B. They are obscured by the bright light of the surrounding star, which is typically 100,000 times brighter than the disk.
C. They are often too small to detect with current telescopes.
D. They dissipate quickly, limiting the time they can be observed.

Correct Option: B) They are obscured by the bright light of the surrounding star, which is typically 100,000 times brighter than the disk.

5. Herbig haro 46/47: Cosmic Birth Unveiled

Date Captured: 07-26-2023
Distance: 1470 light-years

- Herbig-Haro 46/47, a tightly bound pair of actively forming stars, was captured in high-resolution near-infrared light by NASA's James Webb Space Telescope.
- It is a young star system only a few thousand years old, offering insights into star formation and mass accumulation over time, potentially modeling how low-mass stars like our Sun formed with their planetary systems.
- The image showcases fiery orange lobes where stars eject gas and dust, regulating their mass, surrounded by a dense blue nebula (Bok globule) that, visible in Webb's near-infrared image, reveals soft orange edges and distant stars and galaxies.
- This image opens research prospects into early star formation, mass accumulation processes, and the interaction between young stars and their surrounding gas and dust, offering deeper insights into how stars and planetary systems, including our own, evolve over time.

Q: What effect does turbulence within a molecular cloud have on the star formation process?

A) It consistently increases the rate of star formation across the entire cloud.
B) It can inhibit gravitational collapse by dispersing gas and dust.
C) It has no measurable impact on star formation.
D) It only affects the formation of massive stars, leaving low-mass stars unaffected.

Correct Answer: B) It can inhibit gravitational collapse by dispersing gas and dust.

6. Southern Ring Nebula: Stellar Death's Glow

Date Captured: 07-12-2023
Distance: 2,000 light-years

- The Southern Ring Nebula, located about 2,000 light-years away, is a planetary nebula—an expanding shell of gas and dust ejected from a dying star.
- Webb's infrared imaging reveals a second, dusty dying star at its center, closely orbiting its companion and ejecting gas and dust to form asymmetrical shells, while also uncovering a background filled with distant galaxies, where most of the multi-colored points of light are galaxies rather than stars.
- As one of the nearest known planetary nebulae, the gasses of the Southern Ring Nebula are expanding from the central star at a speed of 9 miles per second.
- Webb's detailed image of the Southern Ring Nebula not only captures the planetary nebula itself but also reveals distant galaxies in the transparent red sections, offering research opportunities to study both nebular evolution and the far-reaching cosmic structures beyond it.

Q: What causes the gases of the Southern Ring Nebula to expand?

A) They are heated by radiation from the central star, increasing their kinetic energy.
B) They are being pushed outward by stellar winds from the surrounding stars.
C) They are expanding due to the pressure from supernova shock waves.
D) They are influenced by gravitational interactions with nearby galaxies.

Correct Answer: A) They are heated by radiation from the central star, increasing their kinetic energy.

7. Pillars of creation: Cradle of Stars

Date Captured: 10-19-2022

Distance: 6,500 light-years away

- Set within the vast Eagle Nebula, located 6,500 light-years away, Webb's near-infrared view showcases the Pillars of Creation in vibrant colors, resembling arches and spires of semi-transparent gas and dust, highlighting a region where young stars are forming or emerging from their dusty cocoons.
- In this NIRCam image, newly formed protostars, characterized by bright red orbs with diffraction spikes, are prominently featured outside one of the dusty pillars, where gas and dust knots collapse under gravity to gradually heat up and form new stars.
- The wavy lines resembling lava are ejections from young stars in the process of formation, as they periodically release jets that collide with surrounding gas and dust, including the thick pillars.
- Webb's updated view of the Pillars of Creation, initially captured by Hubble in 1995, will aid researchers in refining star formation models by providing accurate counts of newly formed stars and measuring gas and dust quantities, ultimately enhancing their understanding of how stars emerge from dusty clouds over millions of years.

Q: Gas and dust knots collapse under gravity to form new stars, requiring heat for their formation. What provides this heat during the development of a protostar?

A. Cosmic background radiation provides the necessary heat for star formation.
B. Heat from nearby stars warms the knots, aiding in protostar formation.
C. Radiation from the surrounding gas contributes to the heat needed for protostar development.
D. Friction from colliding particles heats the material, leading to the formation of a protostar.

Correct option: D) Friction from colliding particles heats the material, leading to the formation of a protostar.

8. Wolf-Rayet 124 (WR 124): Beacon of Stellar Chaos

Date Captured: 14-03-2023

Distance: 15,000 Light years

- NASA's James Webb Space Telescope captured one of its first observations of the rare Wolf-Rayet star WR 124 in unprecedented detail, located 15,000 light-years away in the constellation Sagitta, known for being among the most luminous, massive, and briefly detectable stars.
- WR 124 is one of the most massive and luminous stars in the universe, characterized by intense stellar winds and powerful radiation that significantly affect their surrounding environment.
- Wolf-Rayet stars, like WR 124—30 times the mass of the Sun—are shedding their outer layers, creating characteristic halos of gas and dust. So far, WR 124 has expelled material equivalent to 10 Suns, and as this ejected gas cools, it forms cosmic dust that glows in infrared light detectable by Webb.
- Webb's observations of the rare Wolf-Rayet phase of massive stars provide valuable insights into the origin of cosmic dust that survives supernovae and contributes to the universe's "dust budget," crucial for star and planet formation, while challenging existing dust-formation theories.

Q: Wolf-Rayet stars are classified as extreme Population I stars with spectra characterized by broad emission lines. What defines Population I stars??

A. Population I stars are metal-rich, formed from the debris of earlier stars.
B. Population I stars are the oldest stars, formed from primordial gas.
C. Population I stars are exclusively red giants, formed from the remnants of supernovae.
D. Population I stars are binary systems, formed from merging stars.

Correct Option: A) Population I stars are metal-rich, formed from the debris of earlier stars.

9. IC 5332: Whirls of celestial spirals

Date Captured: 09-27-2022
Distance: 29 million light-years

- This spiral galaxy is situated over 29 million light-years from Earth, with a diameter of approximately 66,000 light-years.
- The galaxy's nearly face-on orientation provides a clear and unobstructed view of its symmetrical spiral arms.
- Observations from Webb have delivered unprecedented detail in the mid-infrared spectrum, uncovering structures typically obscured in visible light by interstellar dust.
- Webb's ability to penetrate dusty regions allows for a more comprehensive understanding of the galaxy's composition and structure, enhancing our knowledge of galactic formation and evolution.

Q: What theory explains the formation of spiral arms in spiral galaxies?

A) The black hole theory, which suggests all galaxies have a central black hole.
B) The density wave theory, which describes gravitational interactions and rotation.
C) The dark matter theory, which posits that dark matter dictates the structure of galaxies.
D) The supernova theory, which states that supernova explosions create spiral patterns.

Correct Answer: B) The density wave theory, which describes gravitational interactions and rotation.

10. Arp 142: The Cosmic Dance of the Egg and the Penguin

Date Captured: 07-12-2024
Distance: 326 million light-years

- This pair consists of the Penguin (NGC 2936) and the Egg (NGC 2937), engaged in a dynamic cosmic dance that began between 25 and 75 million years ago.
- The interaction has triggered new star formation in the Penguin, while the Egg remains relatively unchanged, highlighting differences in their structures and compositions.
- The image allows scientists to see through dust and gas that usually obscures such interactions in visible light, providing insights into ongoing processes of star formation and gravitational dynamics.
- These findings enhance our understanding of galaxy evolution and the life cycles of galaxies, contributing to the broader knowledge of cosmic interactions.

Q: What is the reason that the interaction between the Penguin (NGC 2936) and the Egg (NGC 2937) has led to new star formation in the Penguin but not in the Egg?

A) The Penguin has a higher concentration of gas and dust, making it more favorable for star formation.
B) The gravitational pull from the Egg compresses the gas in the Penguin, triggering star formation.
C) The Egg's structure is more stable, preventing any changes in its star formation activity.
D) The Penguin is located in a less dense region of space, enhancing its ability to form stars.

Correct Answer: B) The gravitational pull from the Egg compresses the gas in the Penguin, triggering star formation.

11. Cartwheel galaxy: Cosmic Collisions Legacy

Date Captured: 08-02-2022

Distance: 489.2 million light years

- Also known as ESO 350-40 or PGC 2248, this lenticular and ring galaxy is located approximately 500 million light-years away in the constellation Sculptor.
- Webb's powerful infrared imaging captured a detailed composite of the Cartwheel Galaxy and its two smaller companions against a backdrop of numerous other galaxies, revealing new insights into star formation and the central black hole, utilizing data from both NIRCam and MIRI for enhanced clarity.
- The Cartwheel Galaxy, formed from a high-speed collision 400 million years ago, features a bright inner ring and a colorful outer ring expanding outward like shockwaves, creating its unique and rare "ring galaxy" structure.
- This image provides new insights into the Cartwheel Galaxy's evolution, highlighting its current transitory stage after a collision that transformed it
- from a normal spiral galaxy, while Webb's observations reveal details of its past and future changes.

Q: The Cartwheel Galaxy is a ring galaxy, which is less common than spiral, elliptical, and irregular galaxies. Which of the following statements about ring galaxies is incorrect?

A. Ring galaxies have a central core that is compact, low in gas, and primarily composed of older stars, with little recent star formation.
B. Surrounding the core, there’s a gap with very low density, containing almost no stars, light, or gas.
C. They are usually found in central locations of rich galaxy groups and clusters.
D. Beyond the gap, a luminous ring of much younger, hot, blue stars surrounds the core, indicating recent star formation.

Correct option: C) They are usually found in central locations of rich galaxy groups and clusters

12. Galaxy Cluster SMACS 0723: Echoes of the Ancient Cosmos

Date Captured: 11-07-2022

Distance: 4 Billion Light years

- Revealed by President Joe Biden, Webb's first deep field image captures a small patch of sky, roughly the size of a grain of sand at arm's length, unveiling thousands of galaxies within that tiny segment of the vast universe.
- Webb's high-resolution near-infrared image reveals faint structures in the galaxy cluster SMACS 0723 as it appeared 4.6 billion years ago, showcasing thousands of galaxies, including the faintest infrared objects ever detected.
- The light from these galaxies traveled billions of years to reach us, allowing Webb to look back nearly a billion years after the Big Bang, with the universe's expansion stretching the light into infrared wavelengths that Webb is designed to detect.
- The JWST's deep field image opens new research prospects into the early universe, allowing scientists to study galaxy formation and evolution shortly after the Big Bang, explore faint, distant objects, and gain insights into the expansion and structure of the cosmos.

Q: The stretching of light from distant galaxies due to the expansion of the universe is referred to as cosmological redshift. What underlying principle explains this phenomenon in the context of the expanding universe?

A. The relative motion of galaxies results in Doppler shifts in their spectral lines.
B. The fabric of space-time itself is expanding, causing wavelengths to elongate.
C. Stellar evolution leads to the loss of energy in light, shifting it to longer wavelengths.
D. The gravitational influence of dark matter causes light to bend, affecting its observed wavelength.

Correct Option: B) The fabric of space-time itself is expanding, causing wavelengths to elongate