

# **JWST Science Questions**

From Gardner et al. 2006, Space Science Reviews.

## ***The End of the Dark Ages: First Light and Reionization***

The key objective of The End of the Dark Ages: First Light and Reionization theme is to identify the first luminous sources to form and to determine the ionization history of the early universe.

- What Are the First Galaxies?
  - When did the first luminous sources arise and what was their nature?
  - What were their clustering properties?
- When and How Did Reionization Occur?
  - Was reionization a single event?
  - What is the ionization history of the universe prior to the final reionization?
- What Sources Caused Reionization?
  - What were the sources responsible for reionization?
  - Were they powered by nuclear fusion or gravitational accretion?
  - How is the evolution of galaxies and black holes affected by the possibly extended period of reionization?

## ***The Assembly of Galaxies***

The key objective of The Assembly of Galaxies theme is to determine how galaxies and the dark matter, gas, stars, metals, morphological structures, and active nuclei within them evolved from the epoch of reionization to the present day.

- When and How Did the Hubble Sequence Form?
  - Where were stars in the Hubble Sequence galaxies formed?
  - When did luminous quiescent galaxies appear?
  - How does this process depend on the environment?
- How did the Heavy Elements Form?
  - Where and when are the heavy elements produced?
  - To what extent do galaxies exchange material with the intergalactic medium?
- What Physical Processes Determine Galaxy Properties?
  - When and how are the global scaling relations for galaxies established?
  - Do luminous galaxies form through the hierarchical assembly of dark matter halos?
- What are the Roles of Starbursts and Black Holes in Galaxy Evolution?
  - What are the redshifts and power sources of the high-redshift ultra-luminous infrared galaxies (ULIRGs)?
  - What is the relation between the evolution of galaxies and the growth and development of black holes in their nuclei?

## ***The Birth of Stars and Protoplanetary Systems***

The key objective of The Birth of Stars and Protoplanetary Systems theme is to unravel the birth and early evolution of stars, from infall on to dust-enshrouded protostars, to the genesis of planetary systems.

- How do Protostellar Clouds Collapse?
  - How do clouds of gas and dust collapse down to the dense cores that form stars?
  - What is the early evolution of protostars?
- How Does Environment Affect Star Formation and Vice Versa?
  - How do very massive stars form?
  - How do stellar winds and ionizing radiation from massive stars affect nearby star formation?
- What is the Initial Mass Function at sub-stellar Masses?
  - Does cloud fragmentation explain low mass star formation, and is there a lower limit to the mass?

- How does the sub-stellar initial mass function depend on metallicity or environment?
- How do Protoplanetary Systems Form?
  - How do circumstellar disks form and evolve?
  - What determines their physical sizes?
  - How do dust grains within the disks form planets?
- What are the life cycles of gas and dust?
  - How do gas-phase molecules interact with dust grains in quiescent cloud cores?
  - How does the formation of a star and planetary system affect the astrochemical evolution of the gas and dust?
  - What is the origin of water and organic materials in a planetary system?

## ***Planetary Systems and the Origins of Life***

The key objective of the Planetary Systems and the Origins of Life theme is to determine the physical and chemical properties of planetary systems including our own, and to investigate the potential for the origins of life in those systems.

- How Do Planets Form?
  - What are the physical processes that lead to planets?
  - How common are giant planets and what is the distribution of their orbits?
  - How do giant planets affect the formation of terrestrial planets?
- How Are Circumstellar Disks Like Our Solar System?
  - What comparisons, direct or indirect, can be made between our Solar System, circumstellar disks (forming solar systems), and remnant disks?
- How Are Habitable Zones Established?
  - What are the sources of water and organics for planets in habitable zones?
  - How are systems cleared of small bodies?
  - What are the planetary evolutionary pathways by which habitability is established or lost?
  - Does our Solar System harbor evidence for steps on these pathways?