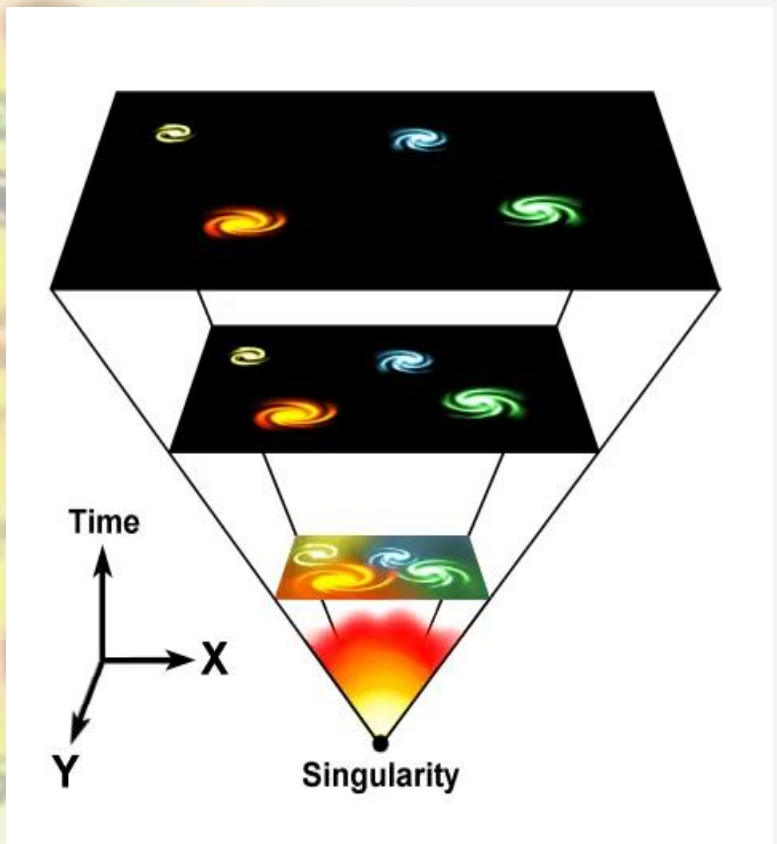
Evolution Of Universe, Stars & Galaxies

Understanding the Universe

- **The Universe:** Everything that exists – matter, space, energy, even things like light and gravity. It's incredibly vast!
- **Size:** Contains around 100 billion galaxies, each with billions of stars. Our own Milky Way galaxy has hundreds of billions of stars.
- **Key Terms:**
  - Cosmos: Another word for the universe.
  - Cosmic: Related to the universe.
  - Cosmology: The science of how the universe began and changes.
  - Astronomy: The science of objects in space (stars, planets, etc.).

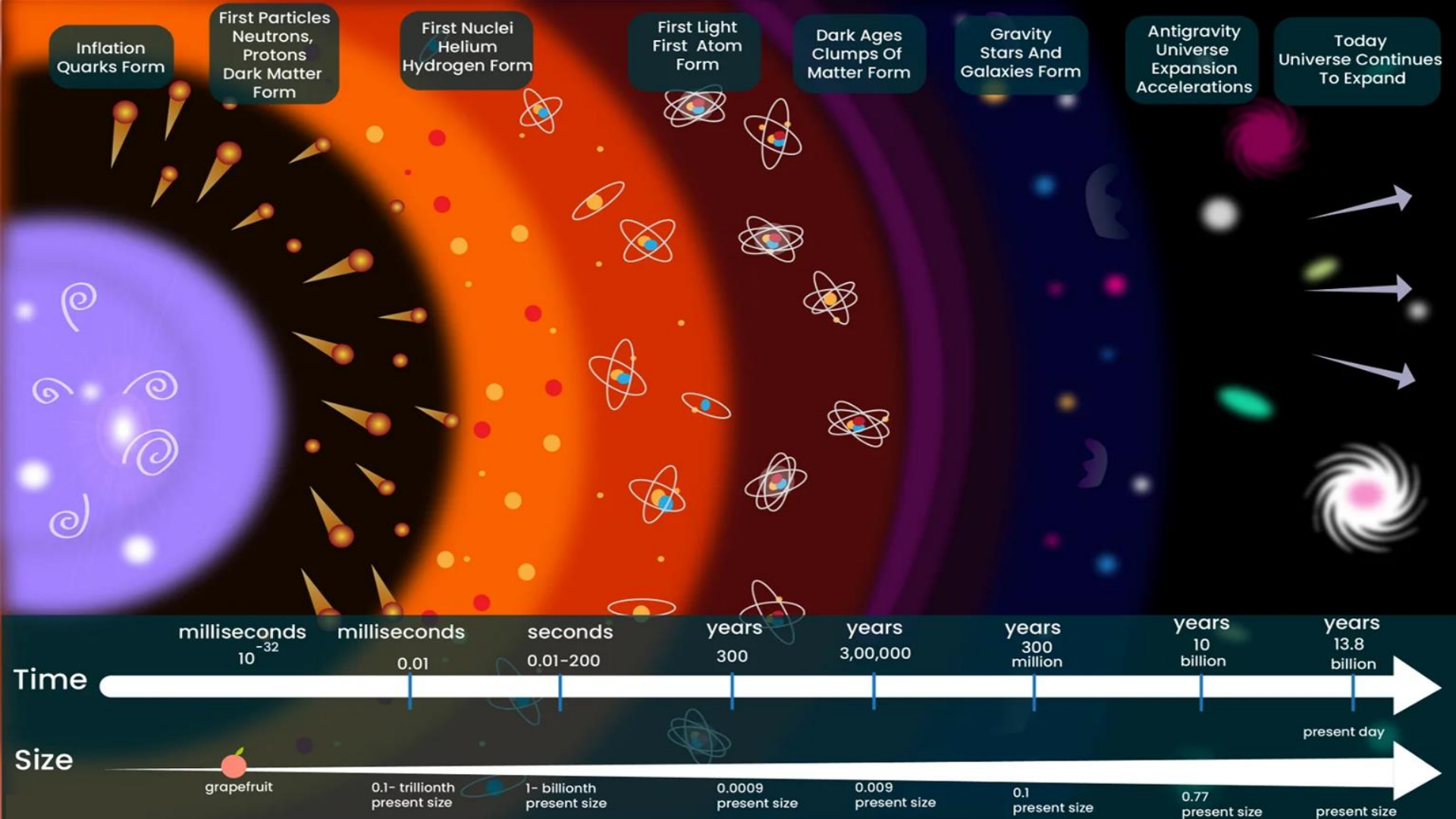


The Big Bang and How the Universe Evolved

- **Big Bang Theory:** The most accepted idea of how the universe began – a massive explosion 13.8 billion years ago. Proposed by Edwin Hubble in 1920, suggesting an expanding universe.
- **Early Universe:**
  - Tiny and super hot.
  - Expanded very quickly in a fraction of a second.
  - Filled with basic particles like electrons and quarks.
- **As Things Cooled:**
  - Quarks formed protons and neutrons.
  - Atoms began to form (mostly hydrogen and helium).
  - Light finally escaped.
- **Billions of Years Later:**
  - Gravity pulled gas together, making the first stars and galaxies.

The Future of the Universe

- **Possible Endings:**
  - Big Crunch: The universe might collapse back in on itself.
  - Accelerating Expansion: The universe will continue spreading outwards, getting colder over time. The cause of this expansion is a mysterious force called "dark energy."


Inflation Quarks Form
First Particles Neutrons, Protons Dark Matter Form
First Nuclei Helium Hydrogen Form
First Light First Atom Form
Dark Ages Clumps Of Matter Form
Gravity Stars And Galaxies Form
Antigravity Universe Expansion Accelerations
Today Universe Continues To Expand
Time
milliseconds
10 -32
milliseconds
0.01
seconds
0.01-200
years
300
years
3,00,000
years
300 million
years
10 billion
years
13.8 billion
present day
Size
grapefruit
0.1- trillionth present size
1- billionth present size
0.0009 present size
0.009 present size
0.1 present size
0.77 present size
present size

STAR FORMATION (Stellar evolution of a life cycle of a star)

The Life Cycle of Stars

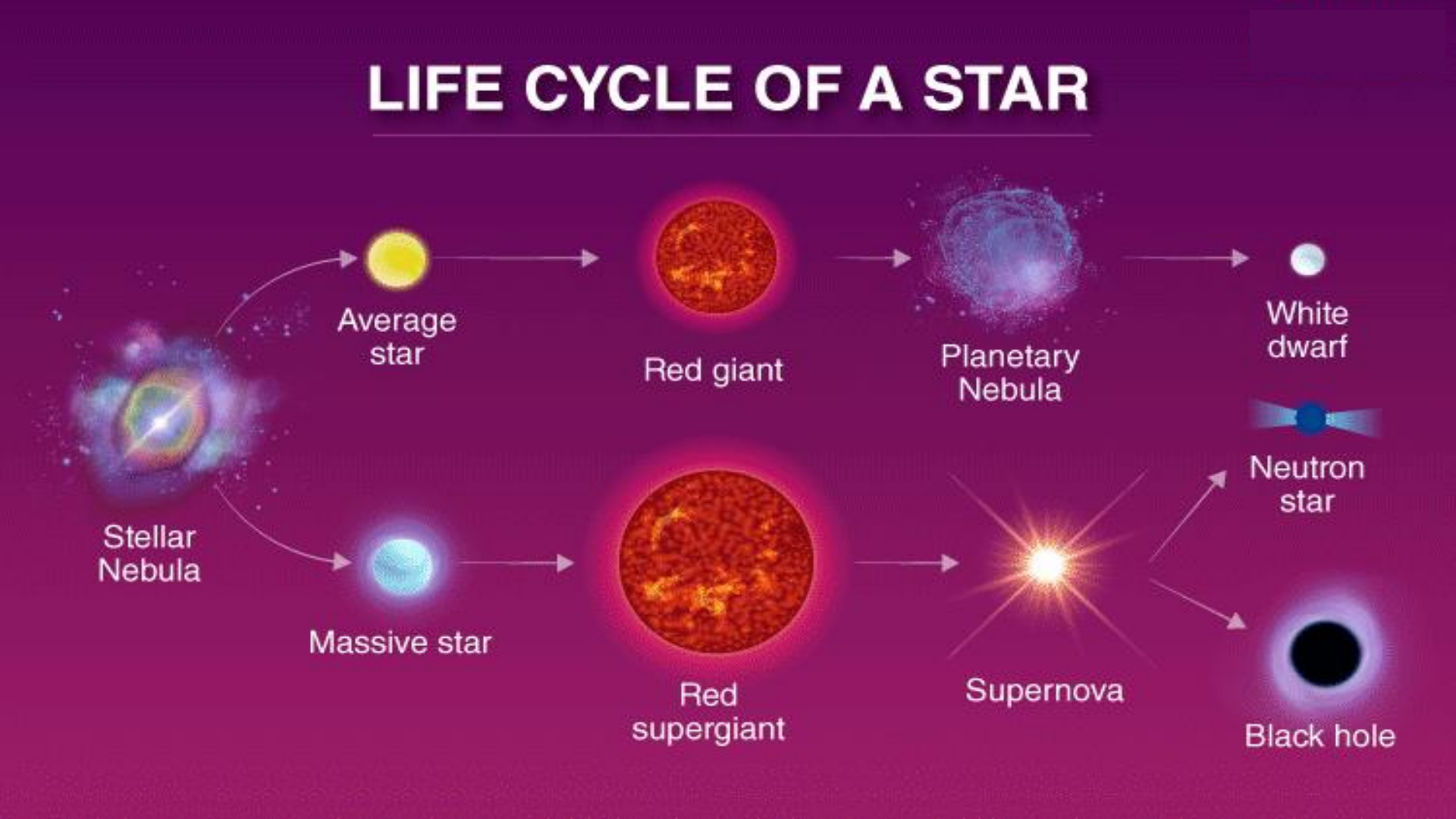
1. **The Beginning: Nebula**

- Stars begin as clouds of gas and dust called nebulae.
- Hot, luminous heavenly bodies, including the sun.
- Composed of hydrogen gas, helium, and dust.
- Hydrogen convert into helium, releasing nuclear energy as heat and light.

2. **Birth and Evolution of a Star:**

- Formation begins with the gathering of Hydrogen & Helium into dense clouds.
- Protostar stage: Gas cloud contracts due to gravity, forming a dense protostar.
- Protostar transforms into a star through further contraction and nuclear fusion.

LIFE CYCLE OF A STAR

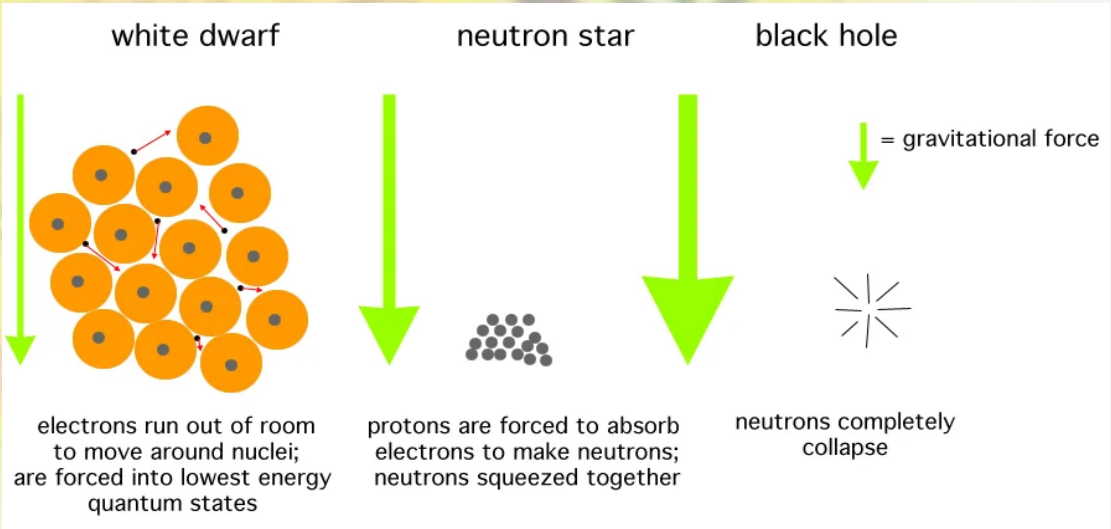


3. Final Stages of a Star's Life:

- Red-Giant Phase: Hydrogen in the core gets converted to helium, leading to expansion and the star becoming a red giant.
- Future depends on initial mass
- Comparable to the sun: Forms a white dwarf after losing its outer shell.
- Much more than the sun: May explode as a supernova, forming a neutron star or black hole.

4. Formation of White Dwarf Star:

- If mass is similar to the sun, red-giant star loses outer shell.
- Core shrinks into a dense ball, initiating fusion reactions converting helium into heavier elements.
- Energy release stops when all helium is converted into carbon.
- Core contracts, becoming a white dwarf star

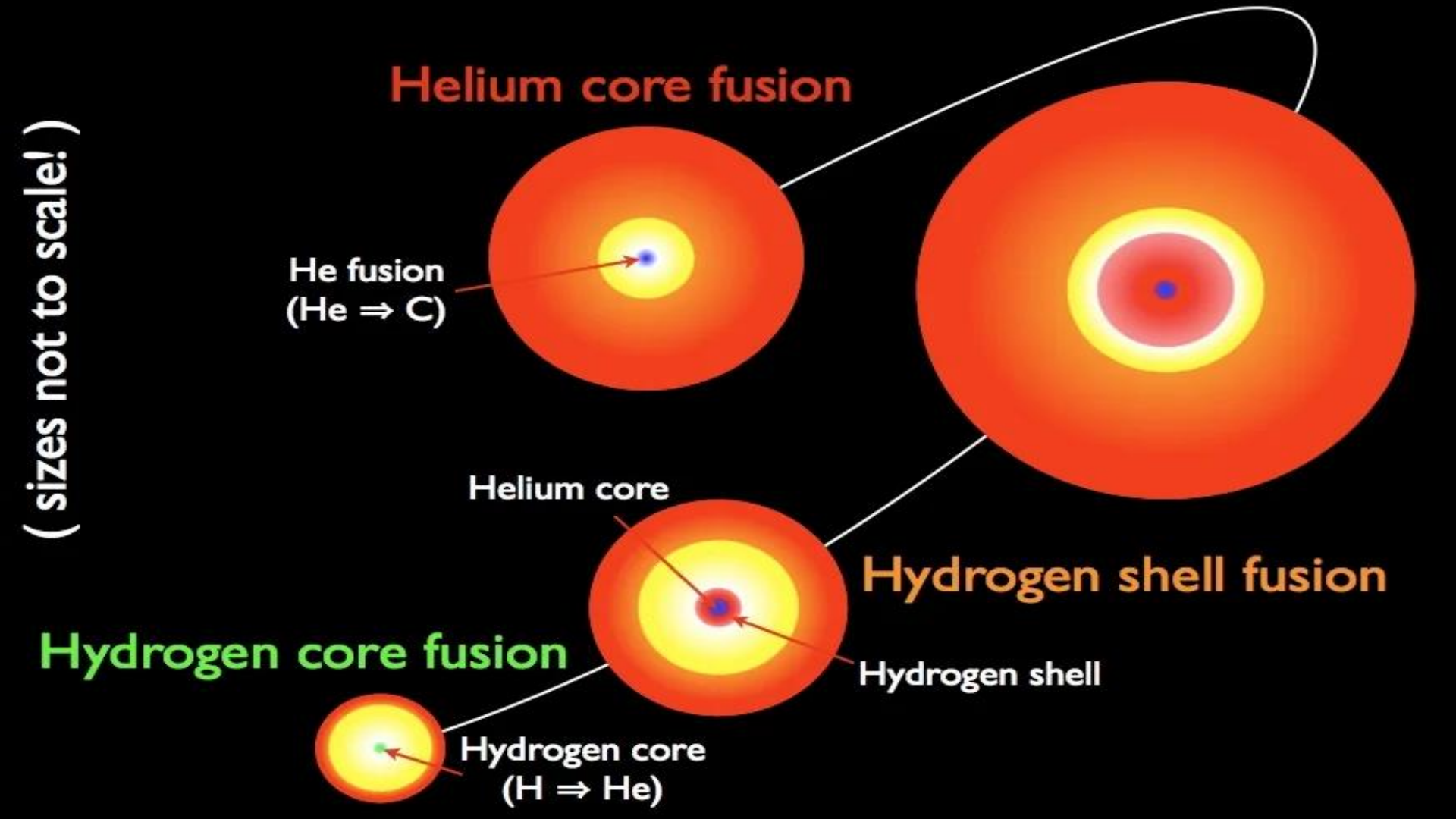


❖ **Chandrasekhar Limit:**

- Maximum mass (1.44 times the solar mass) for a star to end as a white dwarf.
- Exceeding the limit leads to supernova explosions & formation of neutron stars/ black holes.

❖ **Formation of Supernova and Neutron Star**

- Big star in red-giant phase with a large helium core.
- Core contracts, causing fusion of helium into carbon at extremely high temperature.
- Rapid nuclear energy release leads to a supernova explosion, akin to a nuclear bomb.
- Energy released equals the sun's output in about 100 years.
- Supernova explosion scatters gases, serving as raw material for new stars.
- Core left behind becomes a neutron star (mass 1.44 to 3 times the Sun) or Black Hole (mass more than 3 times the Sun).
- Neutron stars contain matter denser than white dwarf stars.


Helium core fusion
(sizes not to scale!)
He fusion
(He ⇒ C)
Helium core
Hydrogen shell fusion
Hydrogen core fusion
Hydrogen shell
Hydrogen core
(H ⇒ He)

❖ **Black Holes**

- Formed when a massive object undergoes uncontrolled contraction due to gravity.
- Neutron star from a supernova explosion can become a black hole if very heavy.
- Infinite contraction packs vast matter into an infinitely dense point object.
- Black holes have strong gravitational forces, preventing even light from escaping.
- Invisible, detected by gravitational effects on surrounding objects.
- First-ever image obtained by the Event Horizon Telescope in 2019.

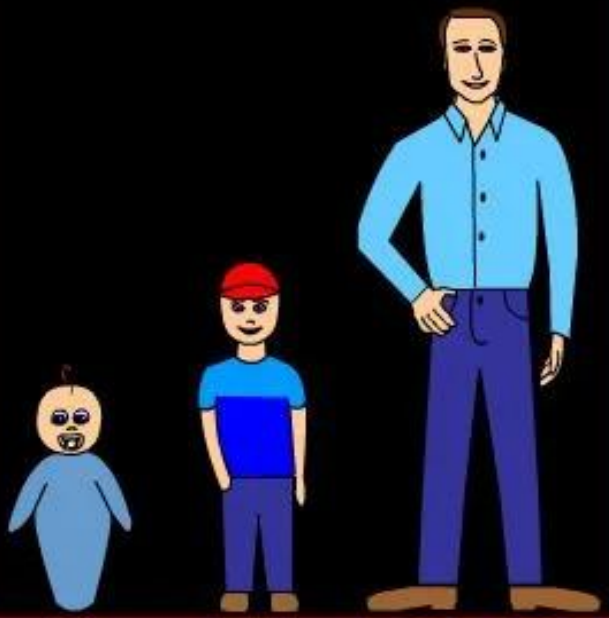
❖ **Dark Matter**

- Hypothesized matter accounting for a large part of the missing mass in the universe.
- Cannot be directly seen with telescopes; emits/absorbs no significant electromagnetic radiation.
- Not a black hole; composition of cold dark matter constituents unknown.

➢ Hecataeus of Miletus- Father of Geography

➢ Eratosthene- Father of Systematic Geography

Protostar	Fusion ignition - Main Squence	Red Giant/Supergiant	White Dwarf/Black Hole
Fetus	Infancy through Adulthood	Middle Age	Old Age-Death



Comparison Diagram of Human lifetime and Star lifetime - Stars and Humans share a similar phases in their lives

❖ **Star Classification**: Classified by physical characteristics: size, color, brightness, and temperature.

- Three primary colors: red (low surface temperature), white (medium surface temperature), and blue (high surface temperature).
- Examples include Polaris, Sirius, Vega, Alpha Centauri, and the Sun.

❖ **Apparent Motion of Stars**

- Stars, except the pole star, appear to move from east to west in the night sky.
- Earth's rotation on its axis causes this apparent motion.

What are Constellations?

- Constellations are groups of stars that form recognizable patterns in the sky. Think of them as 'connect the dots' pictures made with stars!
- Examples: Ursa Major (the Big Dipper), Orion (the hunter), Cassiopeia.

Why do Stars Appear to Move?

- It's not the stars moving, it's us! As the Earth rotates, it makes the stars look like they're circling the sky.

The Special Pole Star

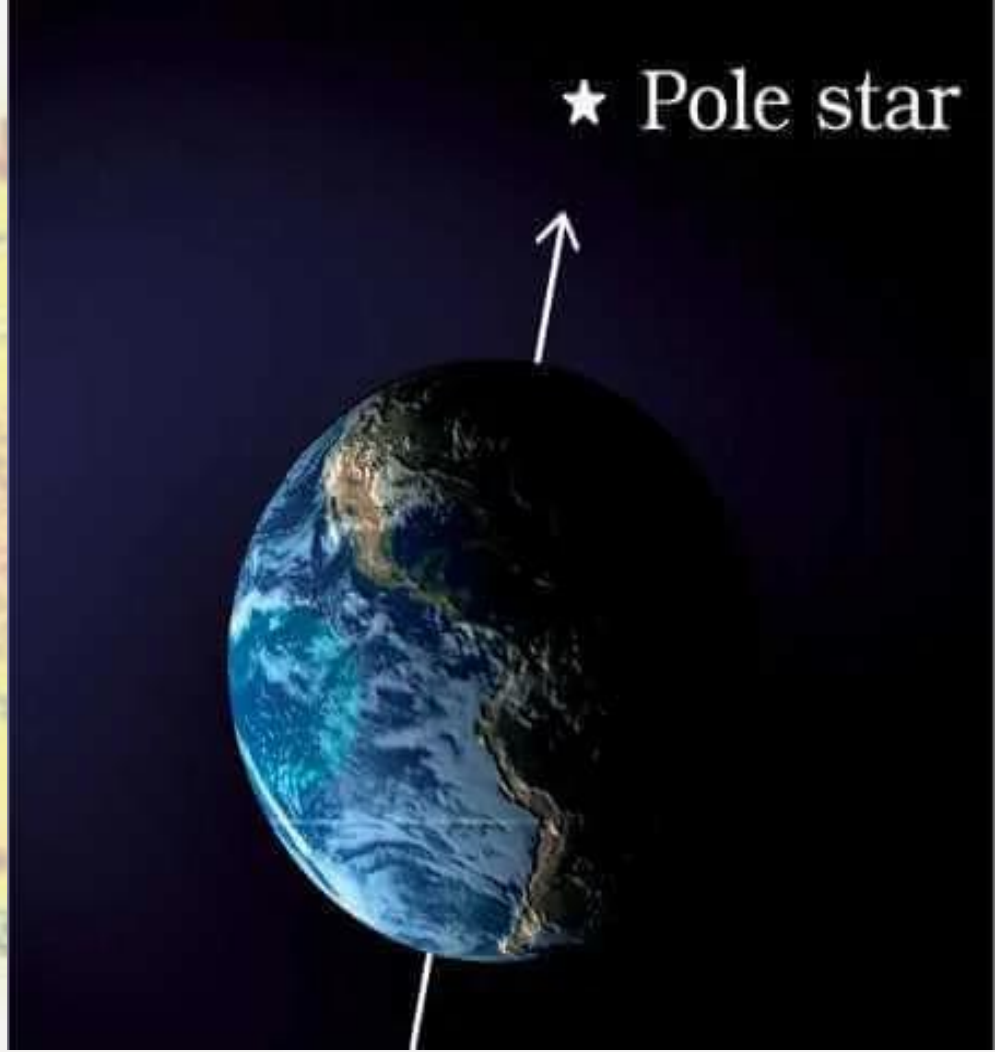
- The Pole Star is a star that lines up with the Earth's axis of rotation. Right now, that star is Polaris (also called the North Star).
- It looks like it doesn't move because we're spinning directly 'beneath' it.
- The Pole Star can help with navigation since it always points North.

Finding Constellations

- Different constellations are visible at different times of year and from different parts of the world.
- You can use star charts or apps to help you find them.

Example: Finding Sirius

- Orion's Belt (three stars in a row) can help you locate Sirius, the brightest star in the night sky.



Galaxies: Giant Star Cities

- Galaxies are massive collections of stars, gas, and dust held together by gravity.
- They come in various shapes:
  - Spiral Galaxies: Disk-shaped with arms, like our Milky Way.
  - Elliptical Galaxies: Oval-shaped, with older stars.

Dark Matter: The Universe's Mystery

- Most of a galaxy's mass is invisible "dark matter."
- We know it exists because of its gravitational effects, but its nature is unknown.

Our Galaxy: The Milky Way

- We live in the Milky Way, a spiral galaxy.
- Key Features:
  - Flat disk with a central bulge
  - 100-400 billion stars
  - Supermassive black hole at the center
  - Sun located in the Orion Arm, about 26,000 light-years from the center

Fun Facts

- Light-year: The distance light travels in one year.
- The Sun takes about 220 million years to orbit the Milky Way.