The Secret Life of Stars-Astrophysics for Everyone

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

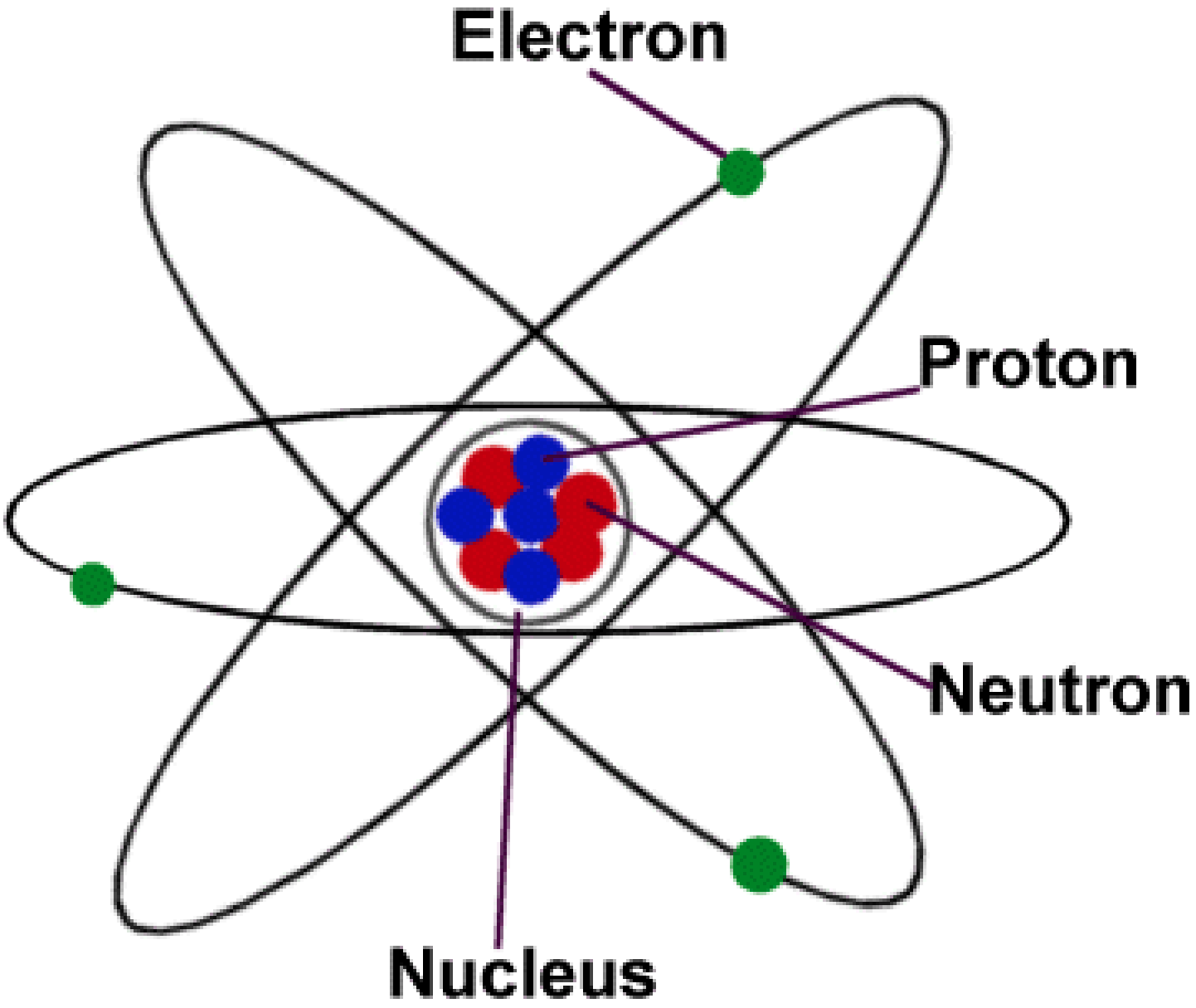
TAURANGA

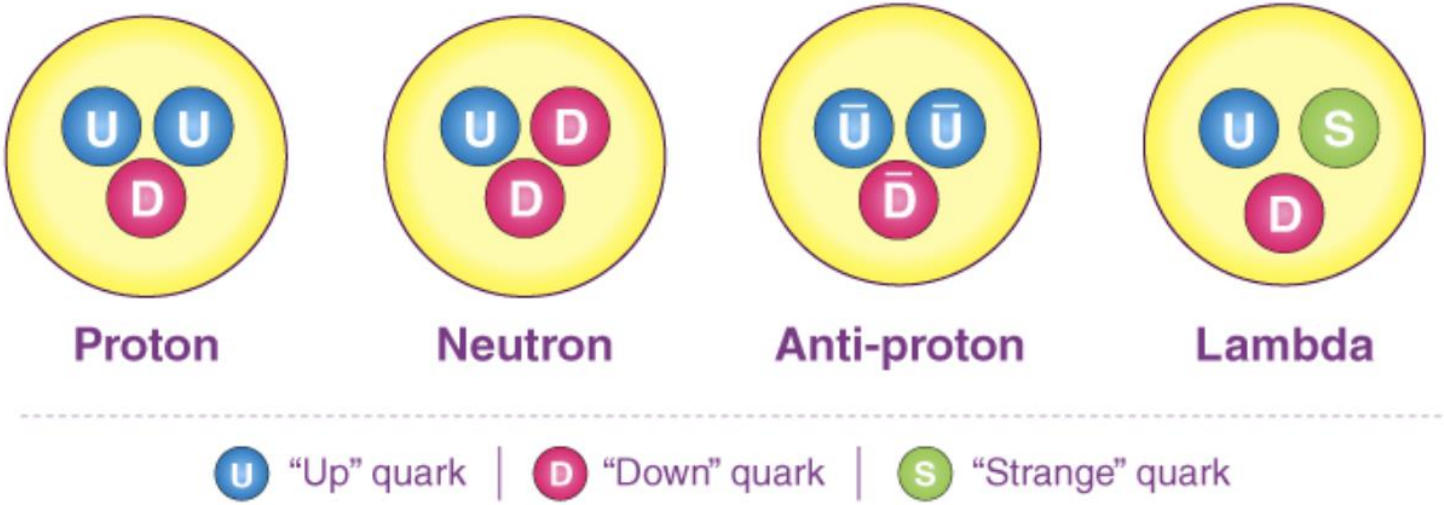
Tauranga Public Lecture
Dr Simon Taylor,
with special guest Rachel Jenkins (piano)
29th June 2026

He maimai aroha ki a Karaitiana Tamatea. Moe mai rā. A tribute to Karaitiana Tamatea (1960-2026)

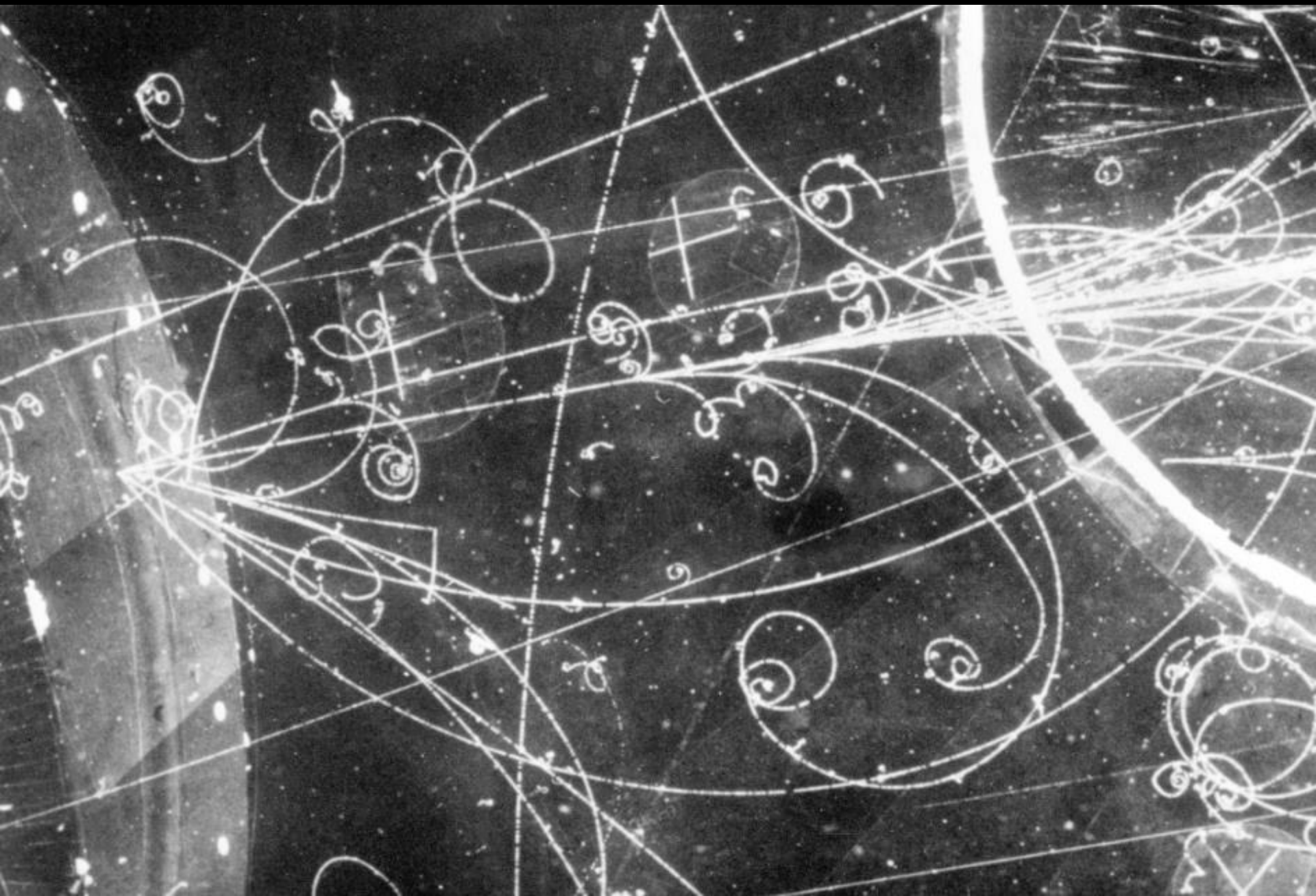
Messier 95 bar spiral galaxy found in the constellation of Leo, taken from the Hubble telescope

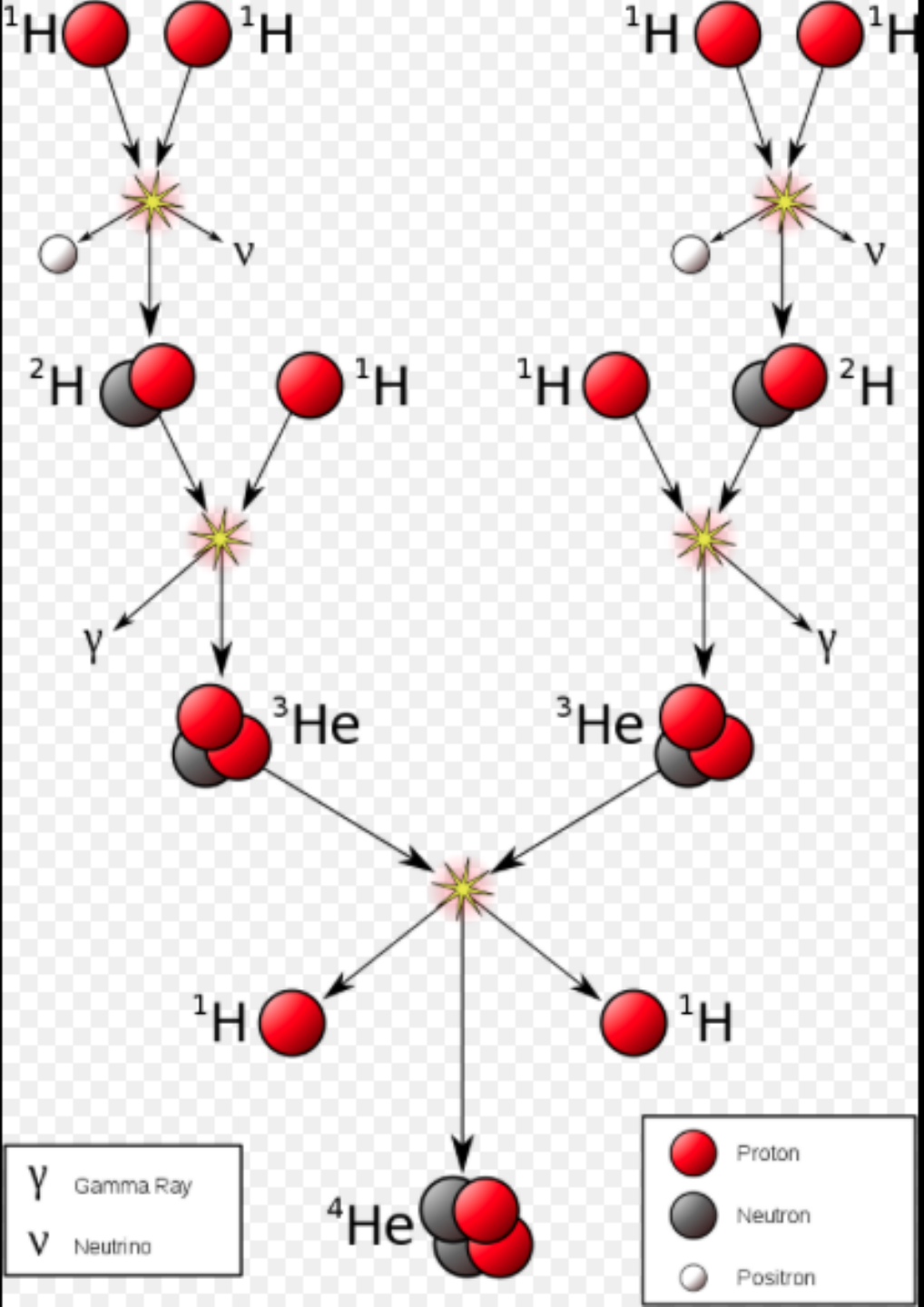
JJ Thompson and Ernest Rutherford


Electron
Proton
Neutron
Nucleus

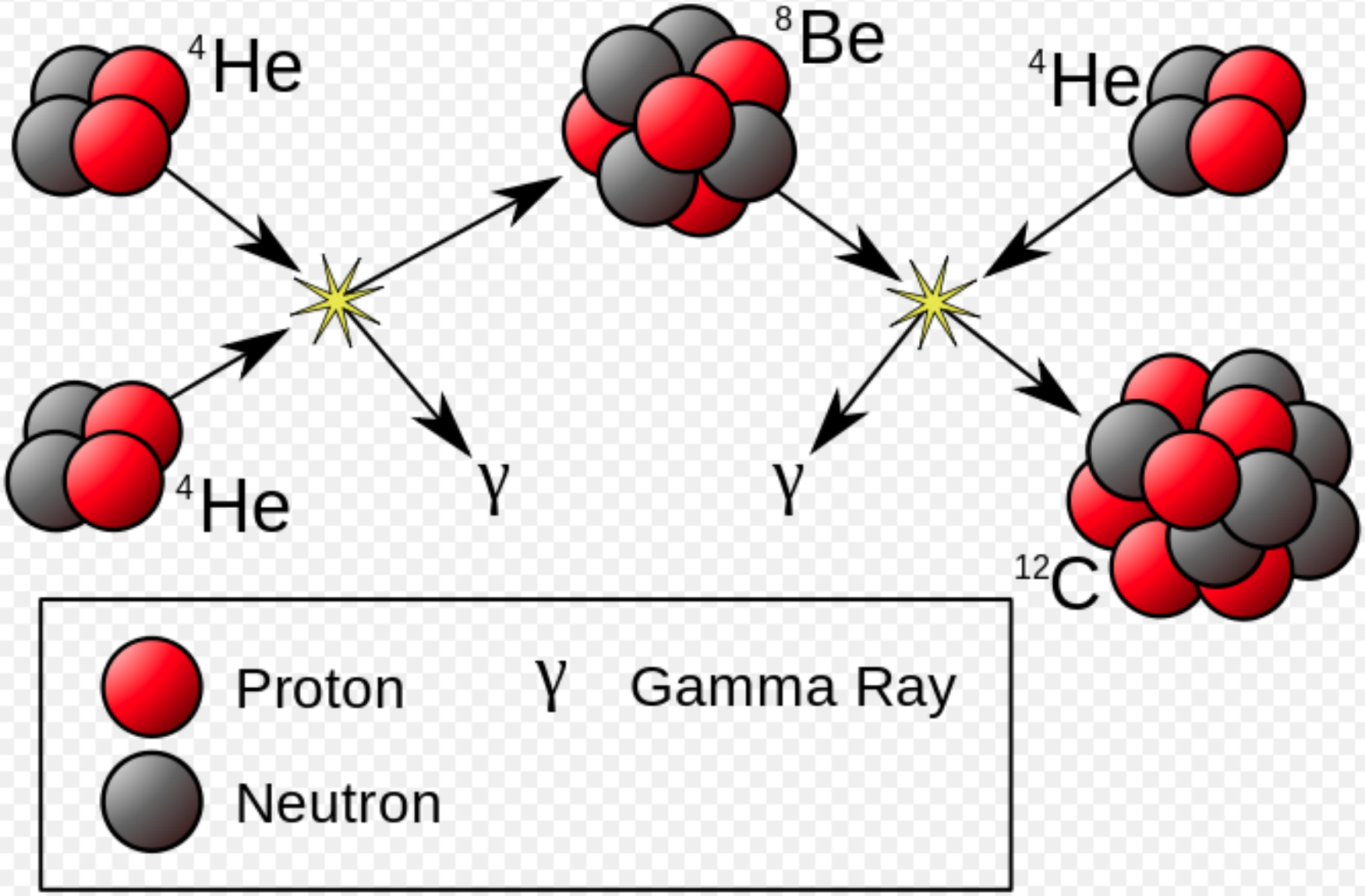

U U D
U D D
Ū Ū D̄
U S D
Proton
Neutron
Anti-proton
Lambda
U "Up" quark
D "Down" quark
S "Strange" quark

The Cosmic Dance

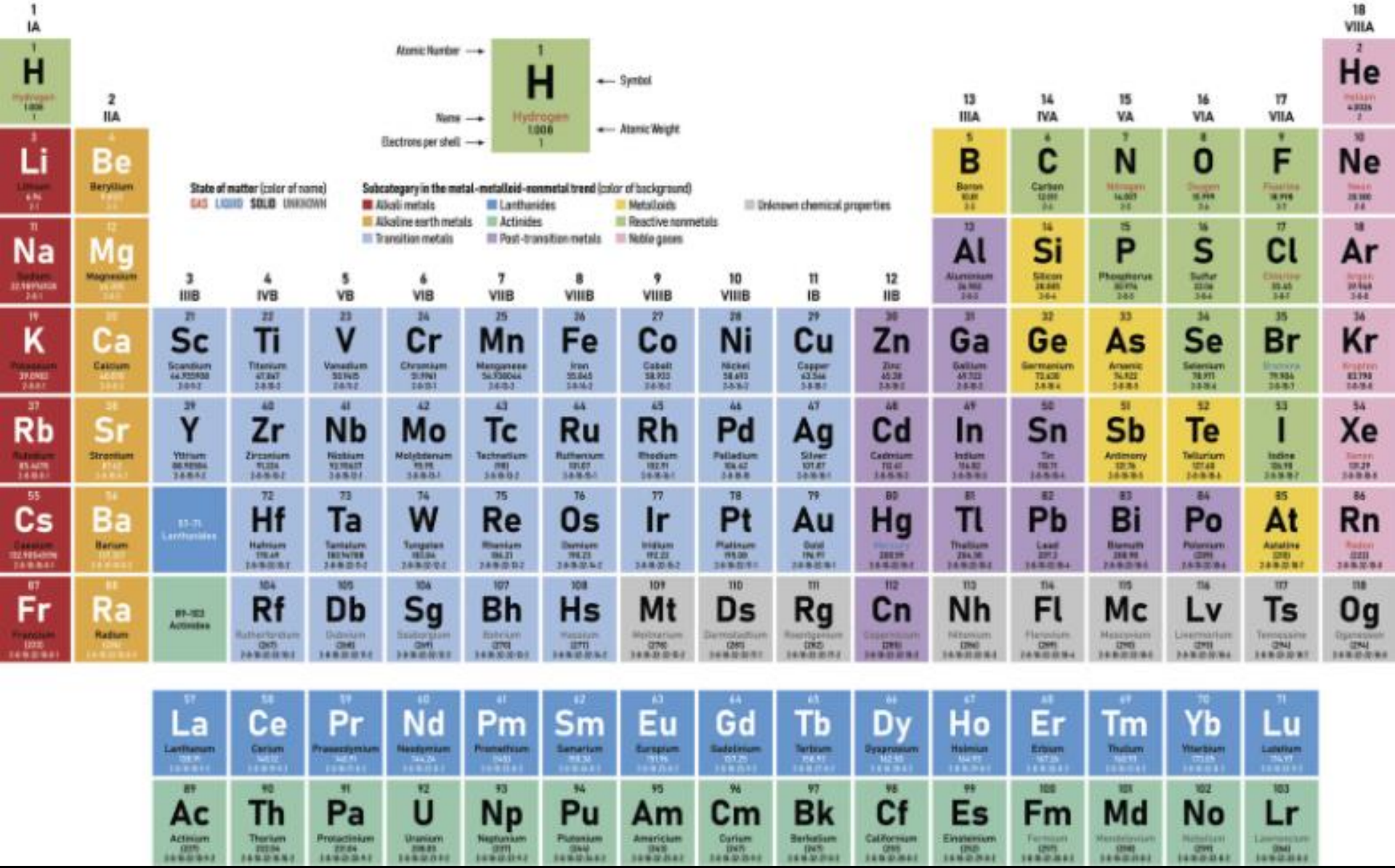


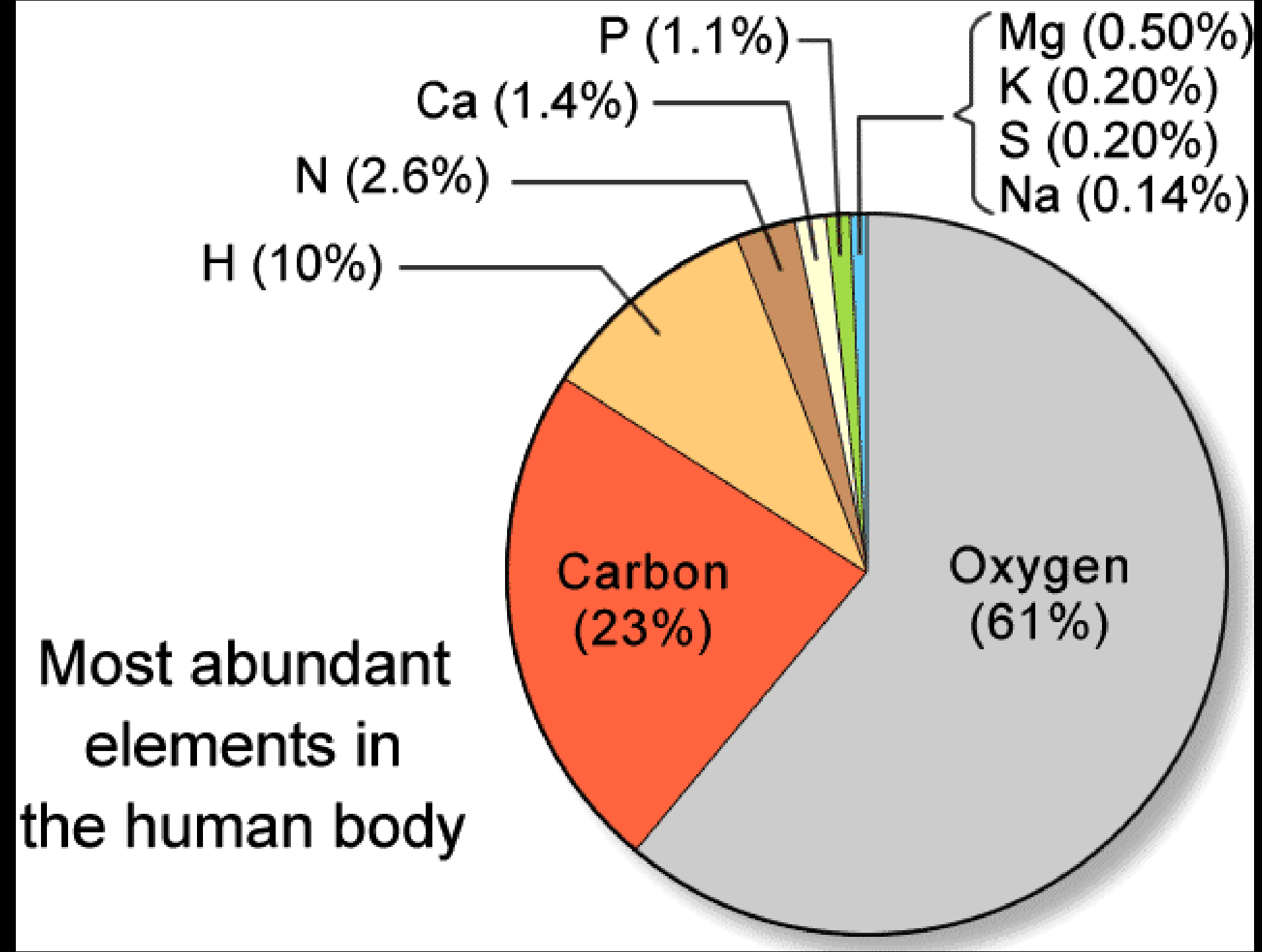


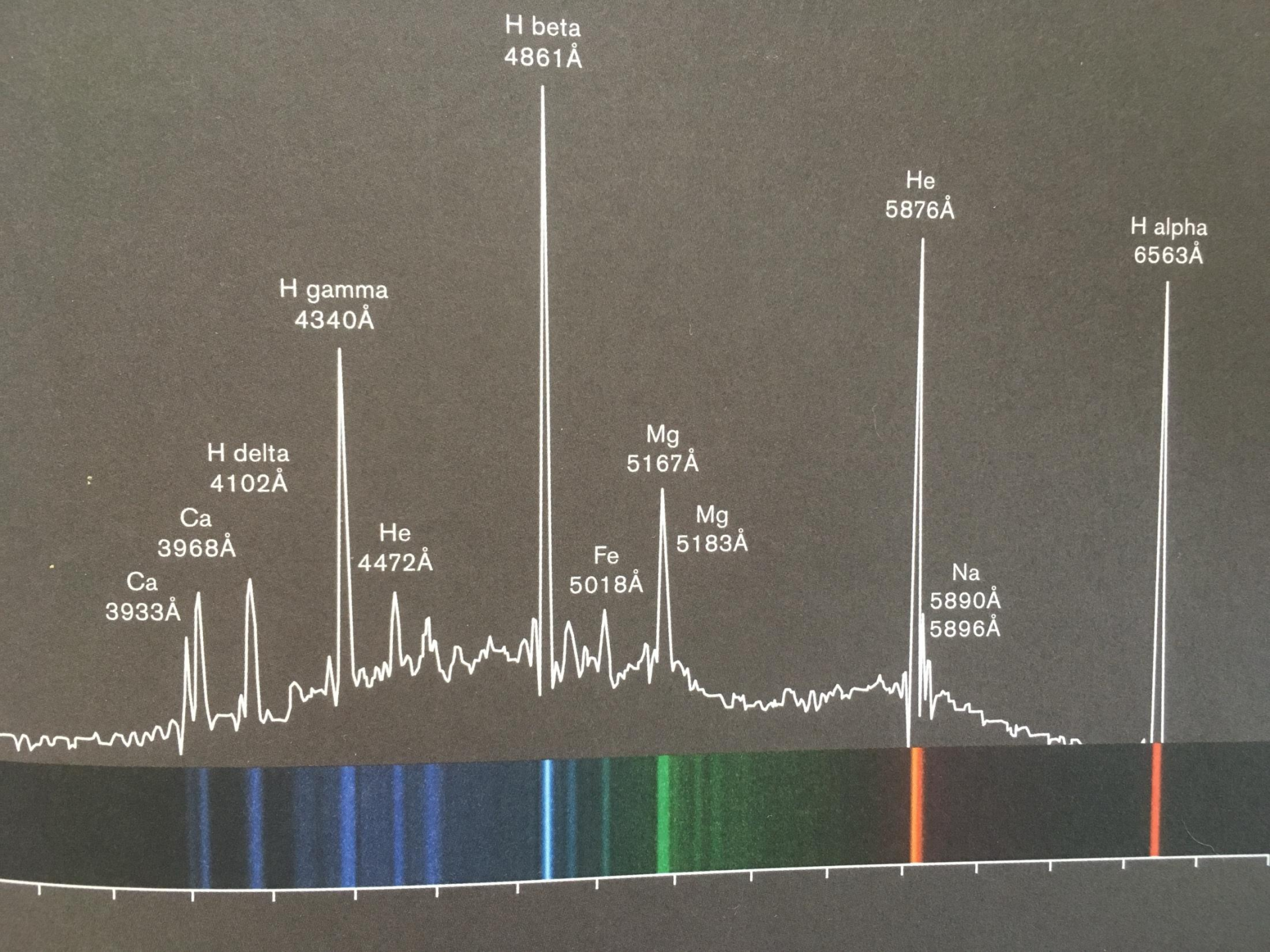
- Hydrogen to Helium
- The all time main reaction in stars
- Nucleosynthesis
- Nuclear fusion
- Cosmic collisions

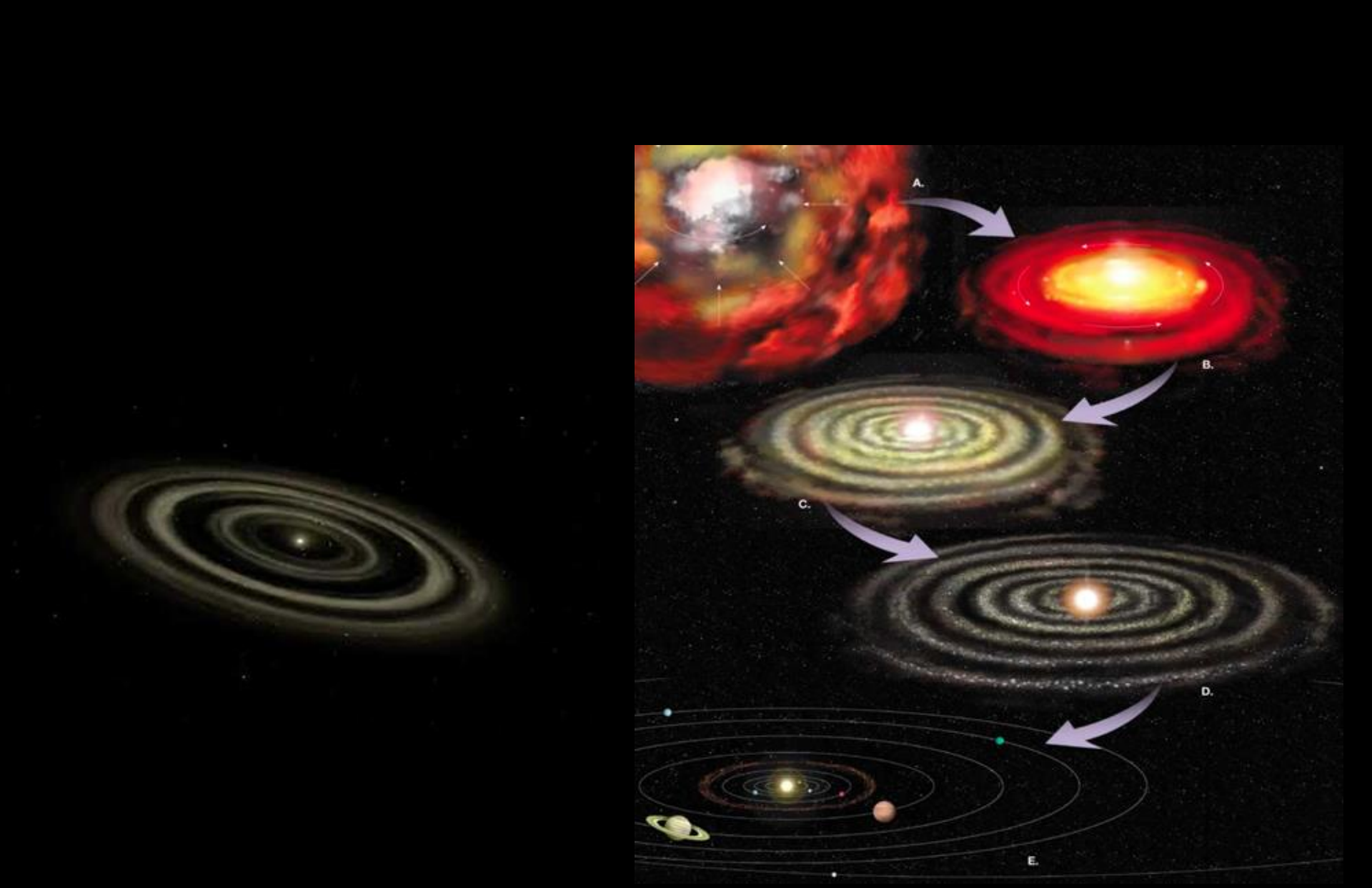

^{4}He
^{8}Be
^{4}He
^{4}He
γ
γ
^{12}C
Proton
γ Gamma Ray
Neutron

Periodic Table of the Elements




P (1.1%)
Ca (1.4%)
N (2.6%)
H (10%)
Mg (0.50%)
K (0.20%)
S (0.20%)
Na (0.14%)
Carbon
(23%)
Oxygen
(61%)
Most abundant
elements in
the human body


H beta
4861Å
He
5876Å
H alpha
6563Å
H gamma
4340Å
H delta
4102Å
Ca
3968Å
Ca
3933Å
He
4472Å
Mg
5167Å
Mg
5183Å
Fe
5018Å
Na
5890Å
5896Å



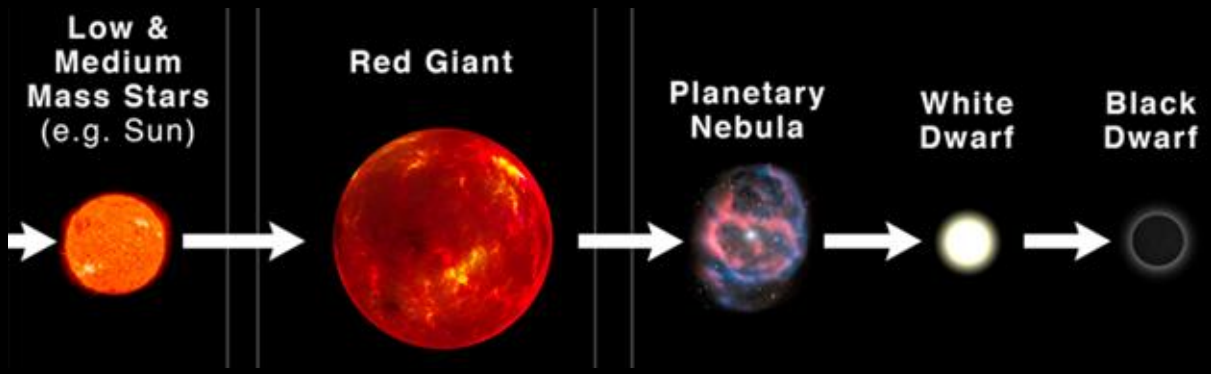
Formation of a proto star, planets are formed as rotation occurs with material left over

Life Cycle - Sun-Sized Star

Planetary Nebula - Fusion of helium → carbon stops when all helium is used, the hydrogen 'red' shell is 'blown' away. These outer layers form a planetary nebula.

White Dwarf - This leaves behind a core of Carbon (smaller than 1.4M_{sun} so no fusion of carbon can occur). A white dwarf radiates heat for billions of years. Overtime, this star continues to cool and redden

Black Dwarf - When all heat is used, the star becomes a dead star made of carbon. It is cold and dark in colour



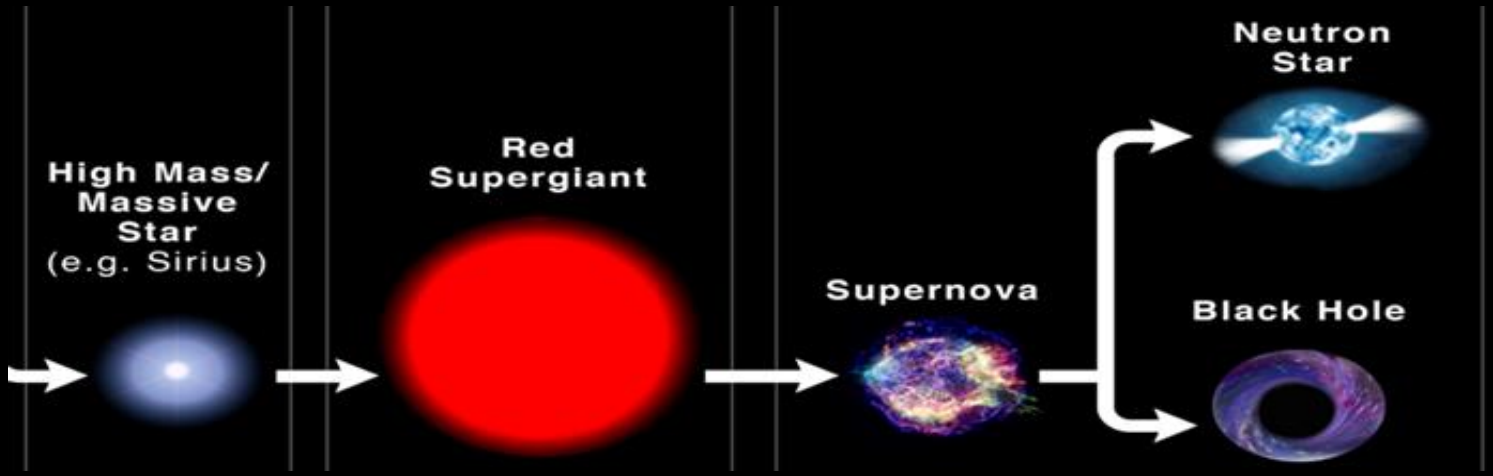
Life Cycle - Huge or Massive Stars

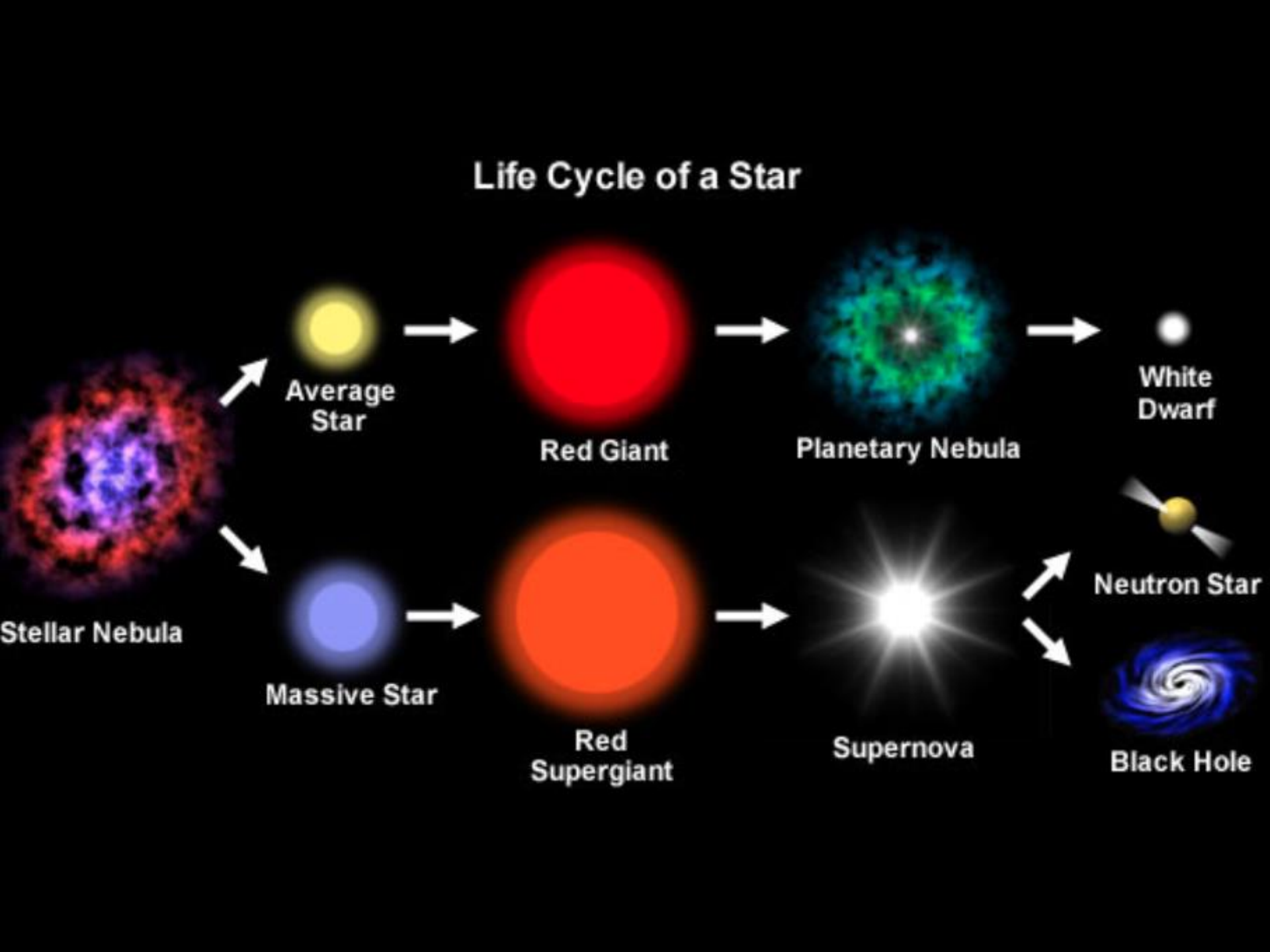
Supernova - the core collapses once Fe is made. Gravity and pressure from electrons cause the core temperature to 100 billion K. Iron atoms becomes compressed and begin to repel each other. These forces overcome gravity and cause a bright, short explosion (a supernova).

Neutron Star - if the core is between 1.5 - 3Msun, it collapses making a small, dense neutron star. It has a strong magnetic field and fast spin

Black Holes - only the largest stars.

The gravity causes the core to collapse in on themselves.




Life Cycle of a Star
Average Star
Red Giant
Planetary Nebula
White Dwarf
Stellar Nebula
Massive Star
Red Supergiant
Supernova
Neutron Star
Black Hole

Different Types of Stars

MASSIVE STAR → supergiant → supernova → blackhole

~ 1 million years

HUGE STAR → supergiant → supernova → neutron star/pulsar

a few million years

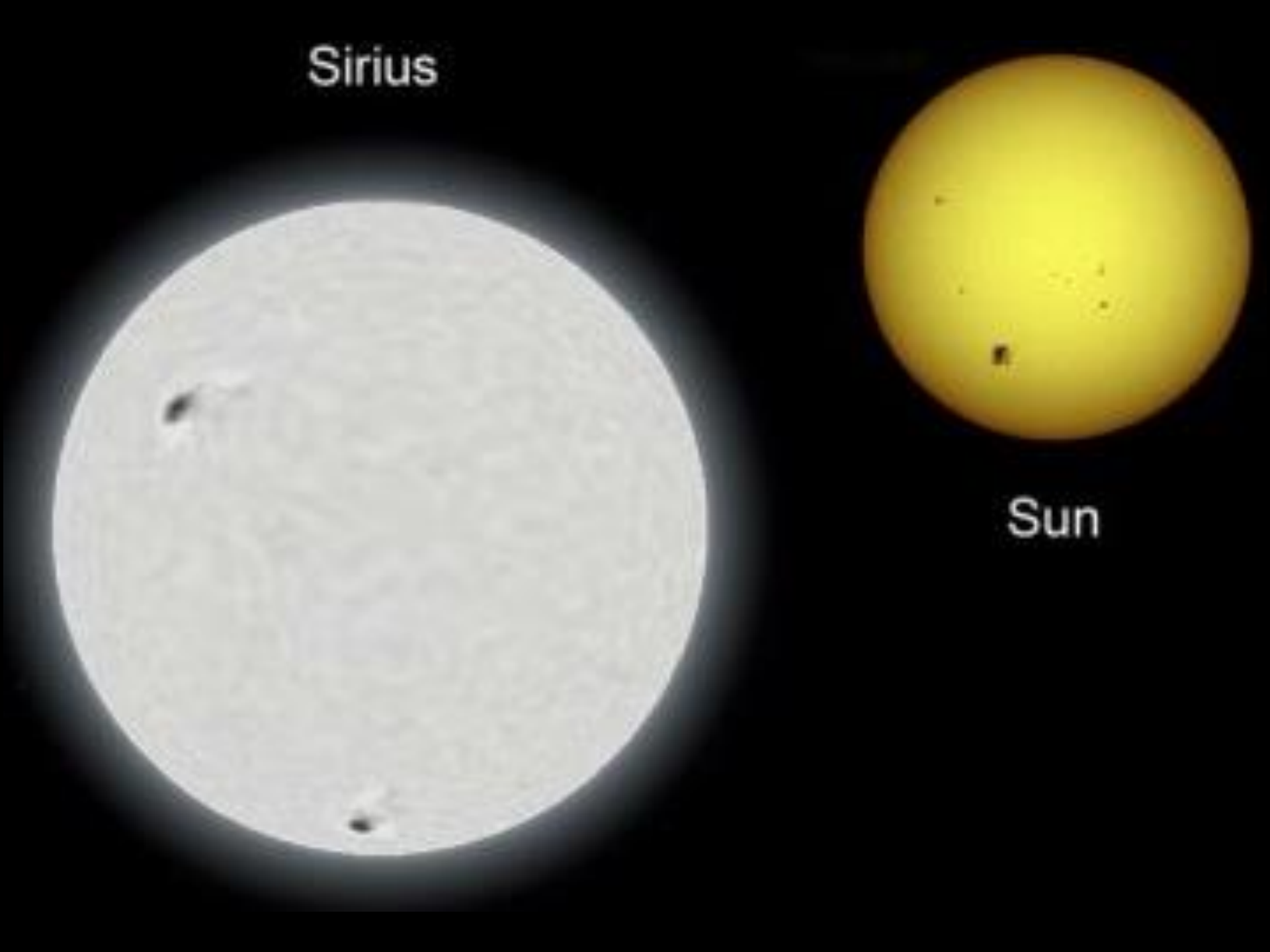
SUN-SIZED STAR → red giant → planetary nebula → white dwarf → black dwarf

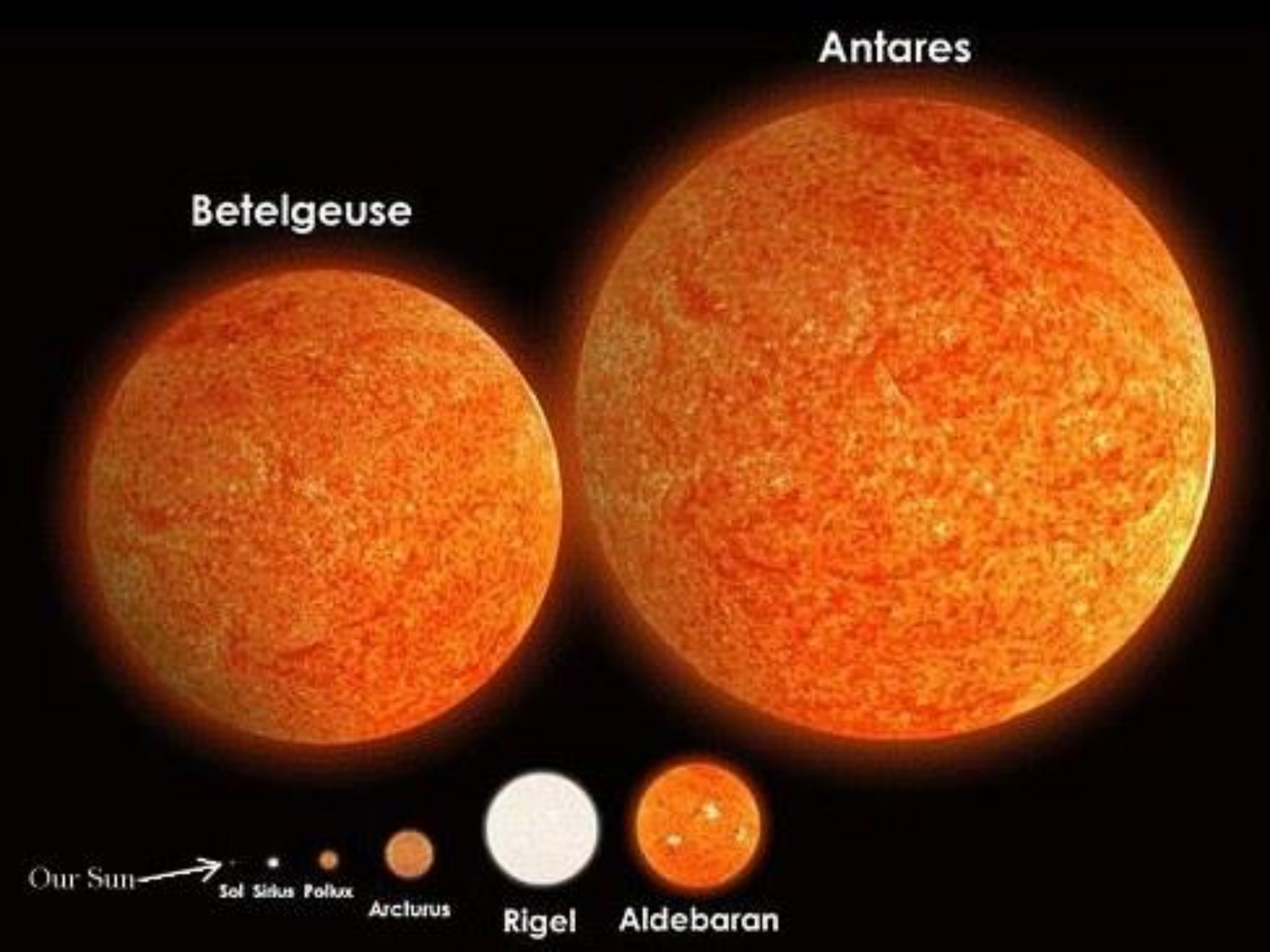
10 billion years

RED DWARF → white dwarf → black dwarf

50 billion years

Messier 57 Planetary Nebula image (a glowing, expanding shell of gas and dust cast off by a dying, low-to-medium-mass star (like our Sun) at


Sirius
Sun


Antares
Betelgeuse
Our Sun
Sol
Sirius
Pollux
Arcturus
Rigel
Aldebaran

White dwarf vs Earth

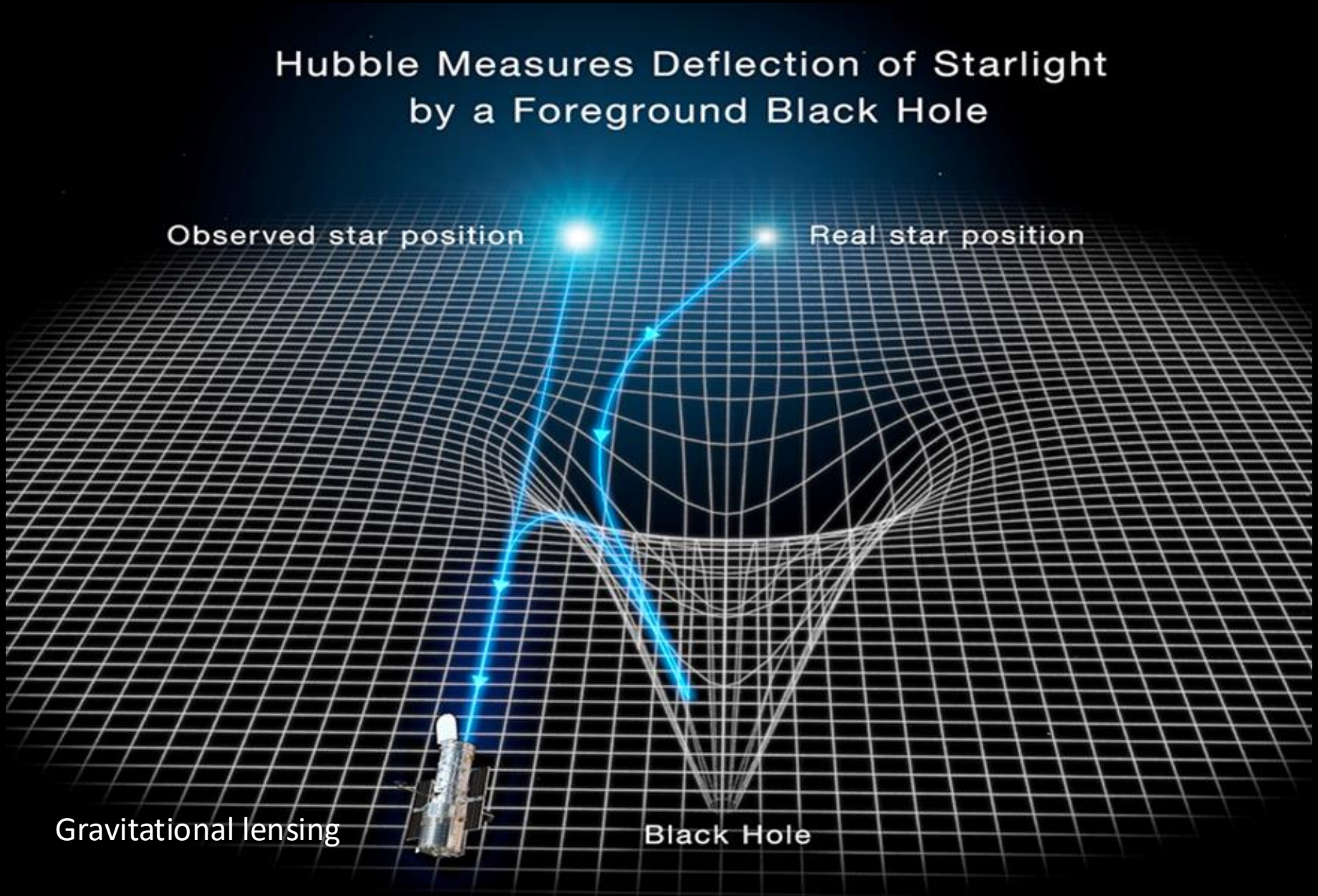
Black Holes

After the supernova, if the core of the star is greater than $3M_{sun}$, a black hole is formed.

Black holes are areas of intense gravity - not even light can 'escape' the gravity, anything that is close enough will be pulled into the black hole

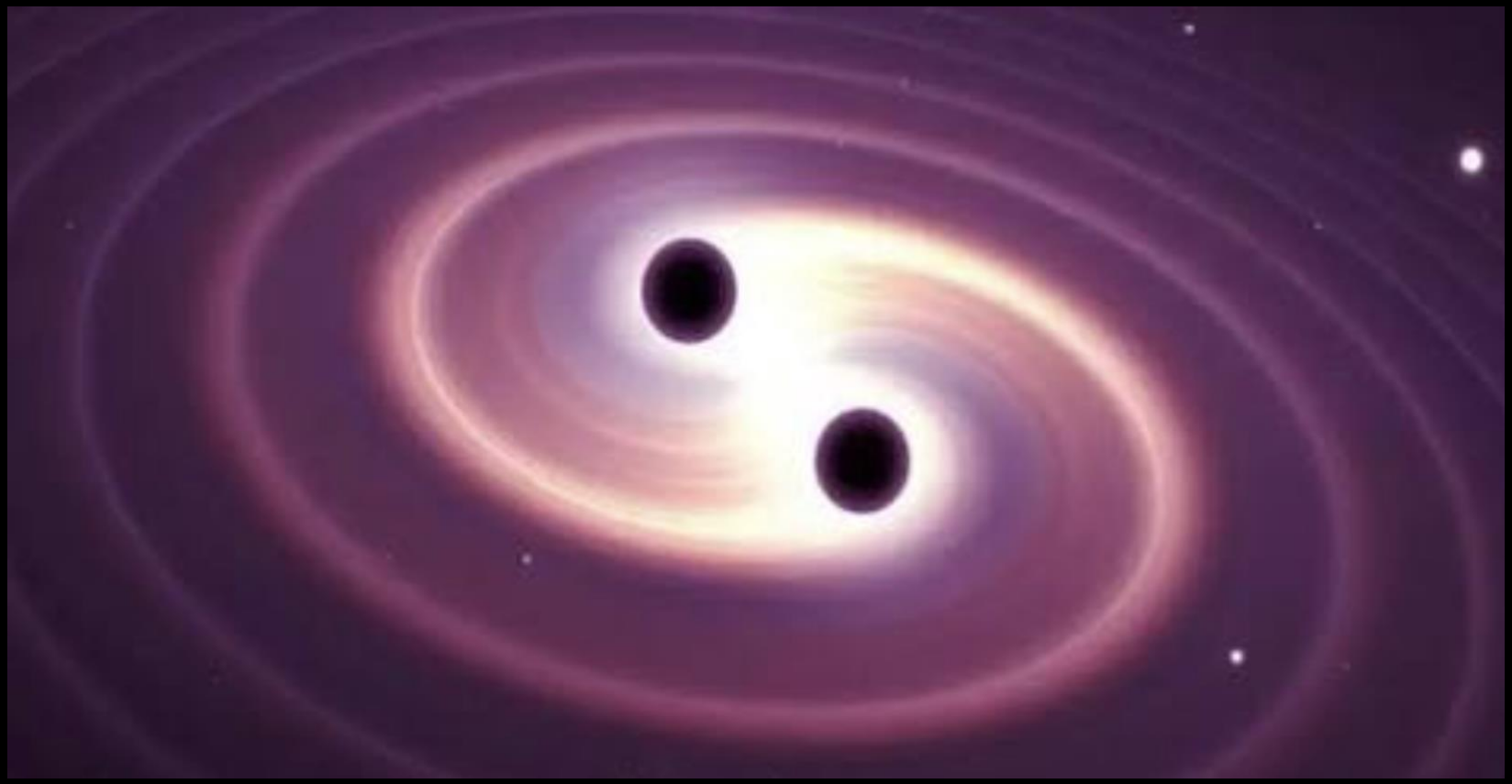
They can't be directly observed as light doesn't escape, but the warping of space around the black hole (due to gravity) can be observed.

Black Holes



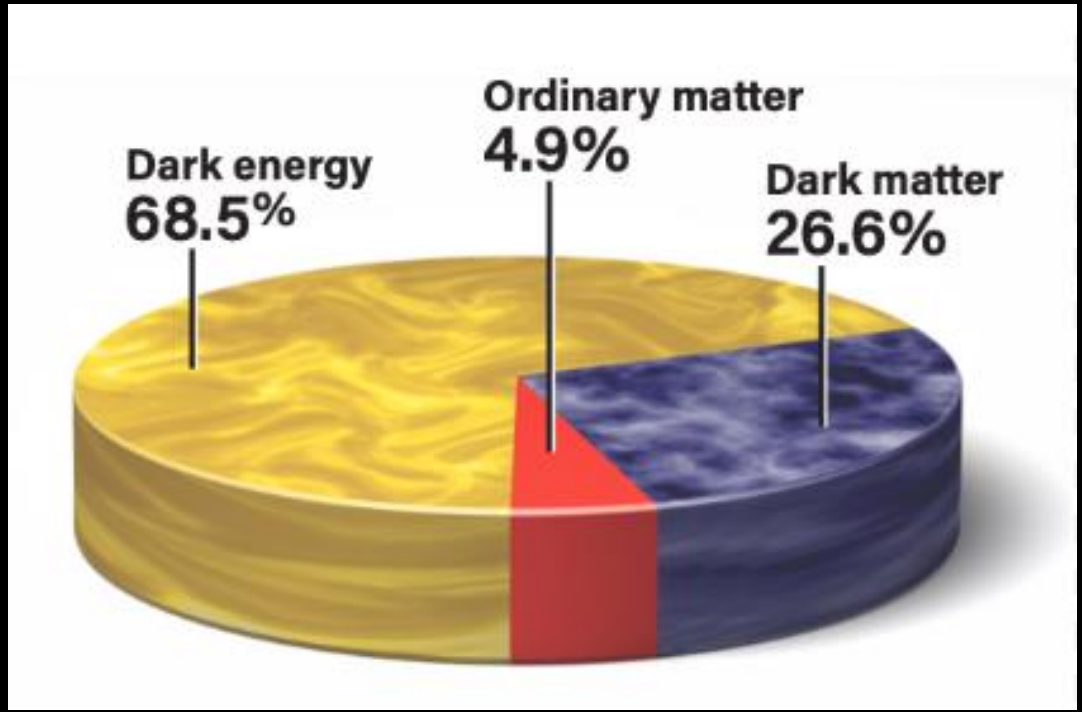
Gravitational lensing

Gravitational waves

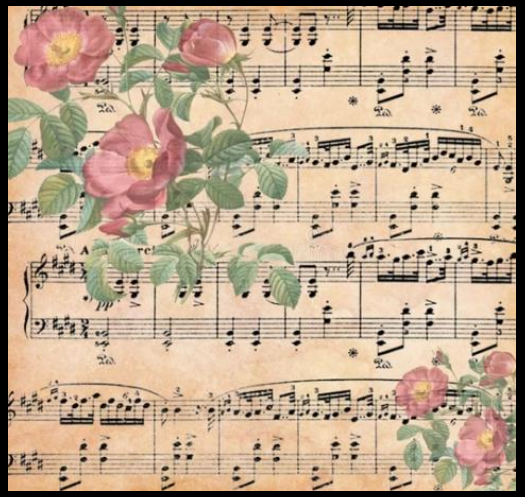


A pair of neutron stars rotating together (artist impression)

The universe is made mostly of dark matter and dark energy



Rachel Jenkins



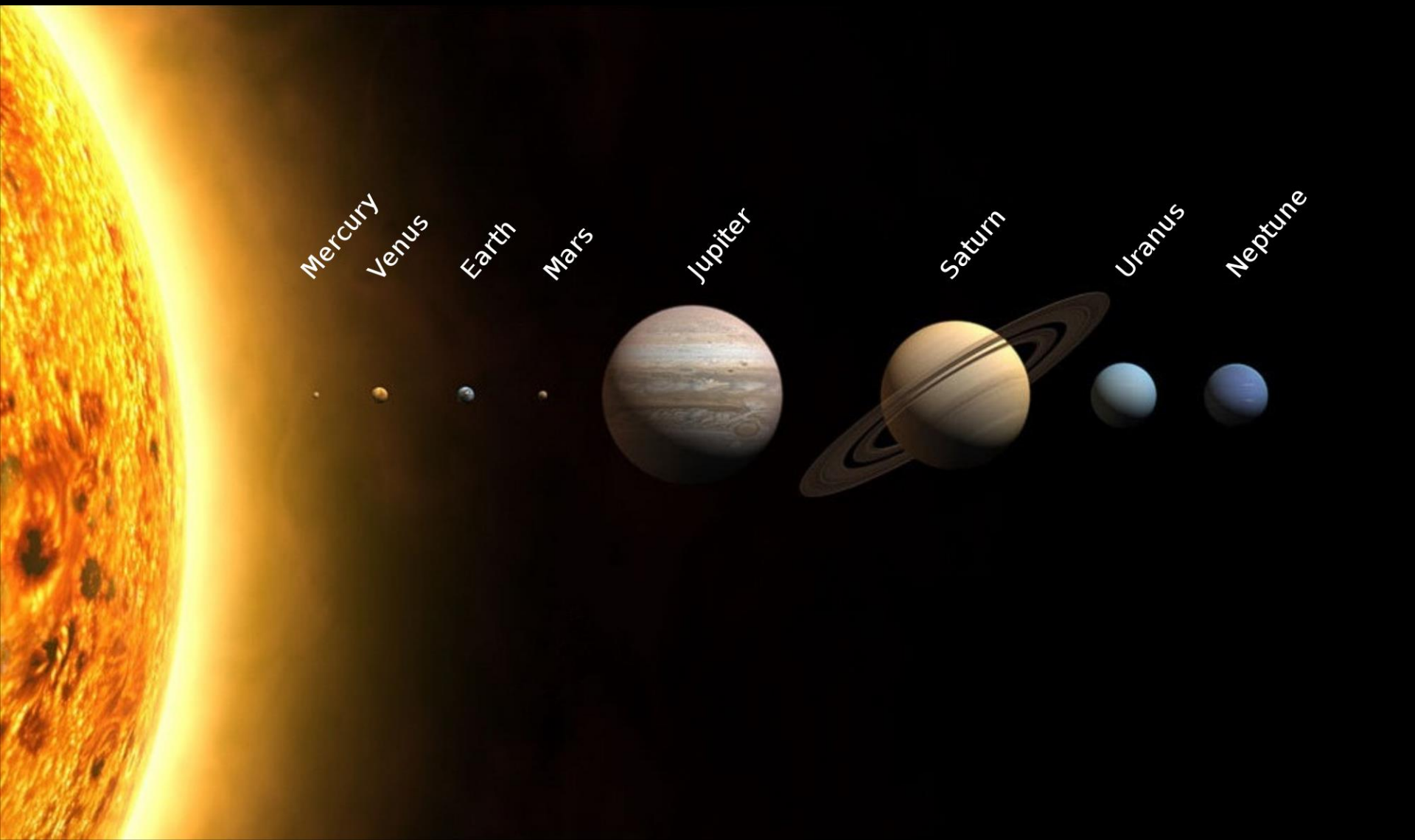
Instead of subatomic particles being hard, solid dots, string theory suggests they are tiny, vibrating strings of energy.

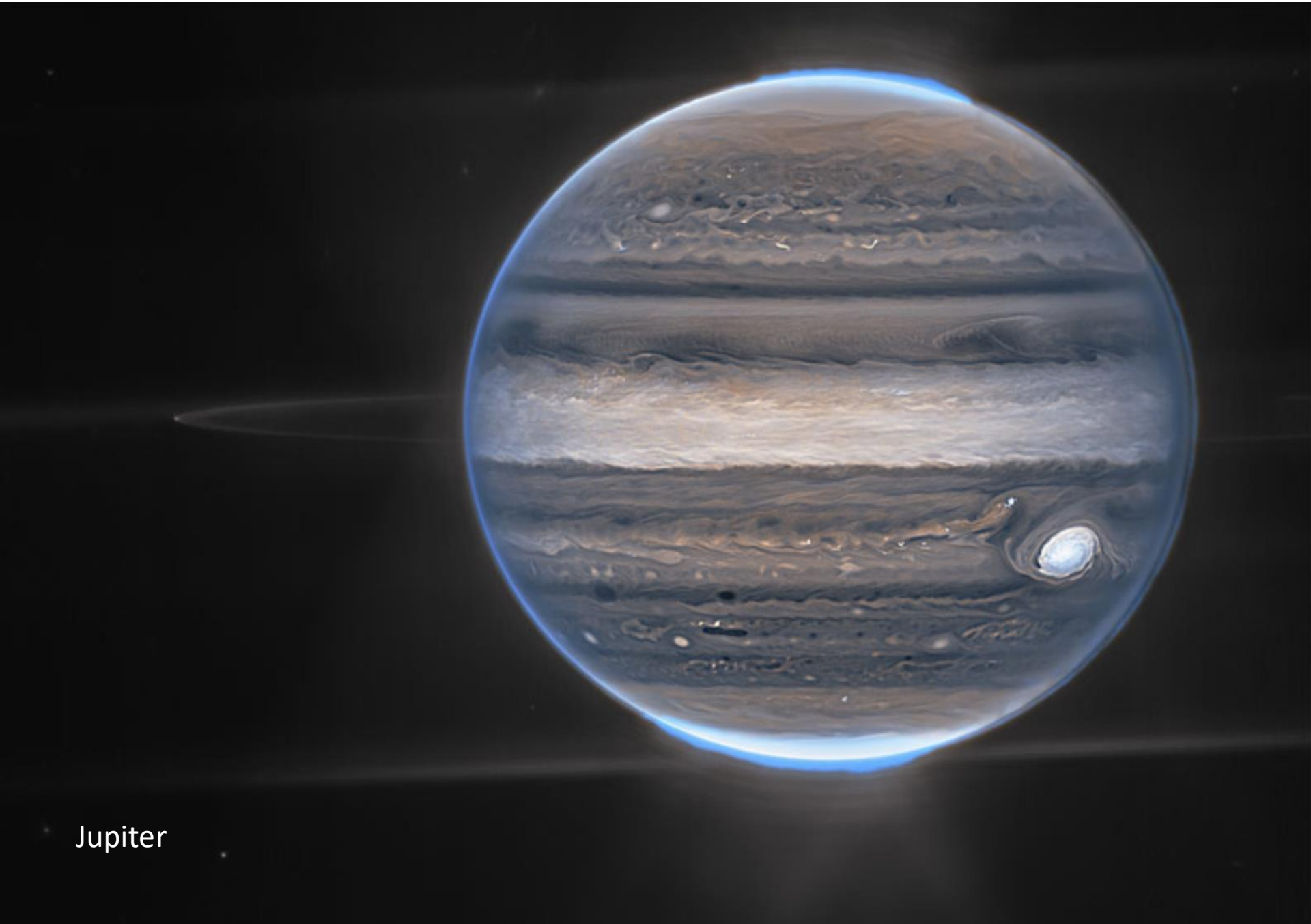
Just as different vibrations on a piano string create different musical notes, different vibrations of these cosmic strings create the different particles in the universe (including the invisible particles that may make up dark matter).

In this view, the universe is essentially a grand symphony.

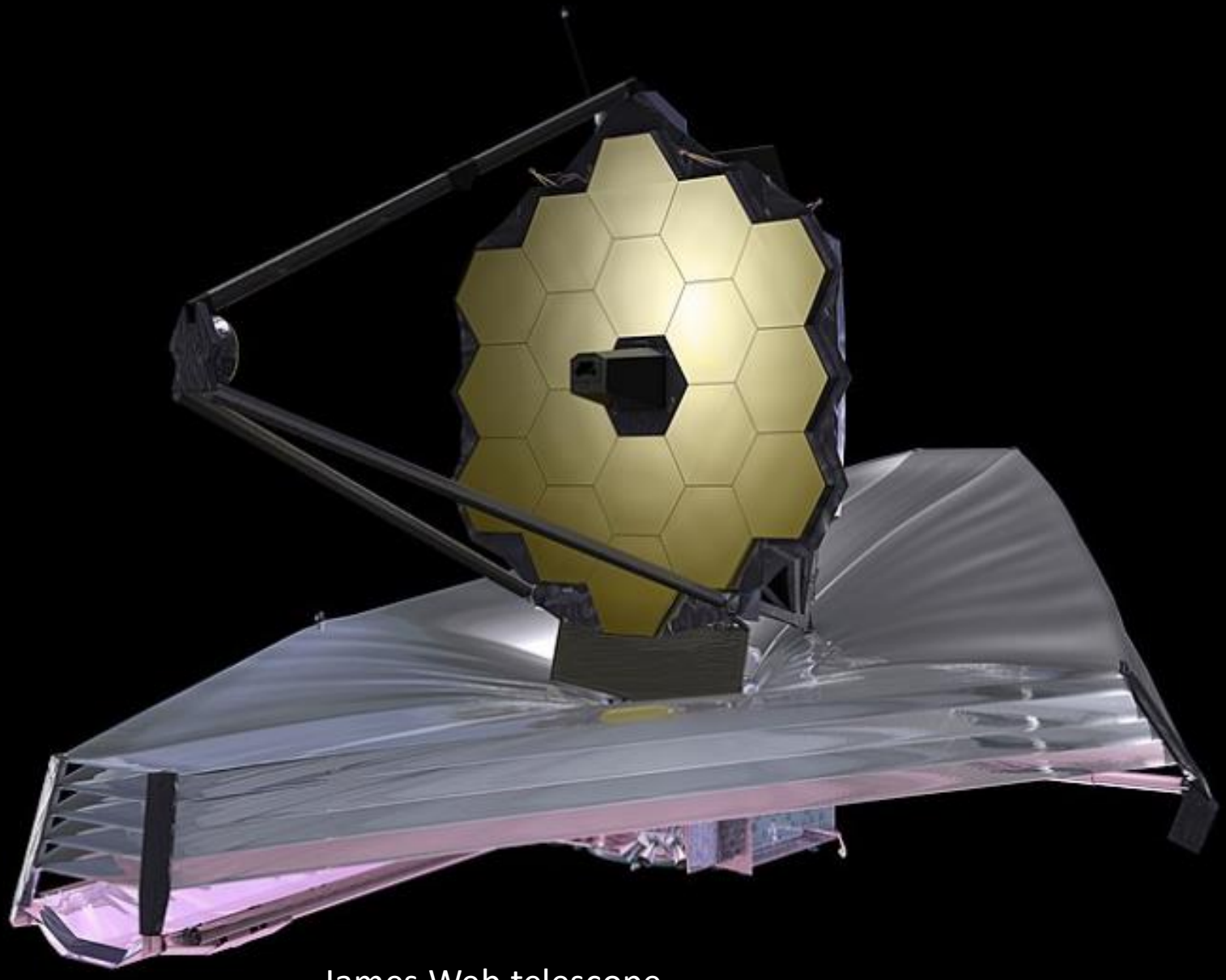
“Sink before the Moon” by Rachel Jenkins

Our solar system





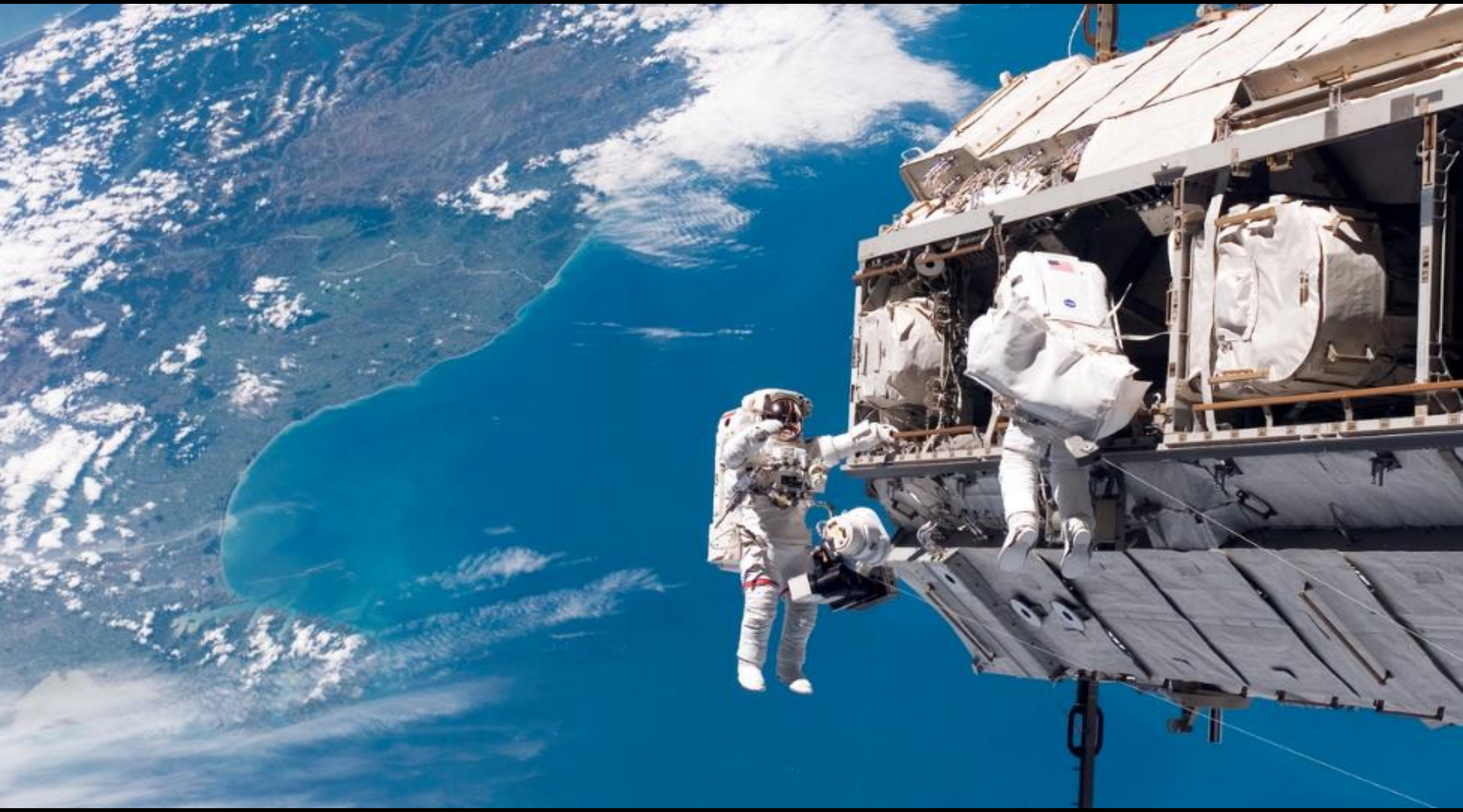
Jupiter



James Web telescope

International space station –view of south island, January 2020
70m long, 100m wide, travels 7.6 km/sec, 400km altitude, ten people on board now, rotates around the Earth every 90 minutes

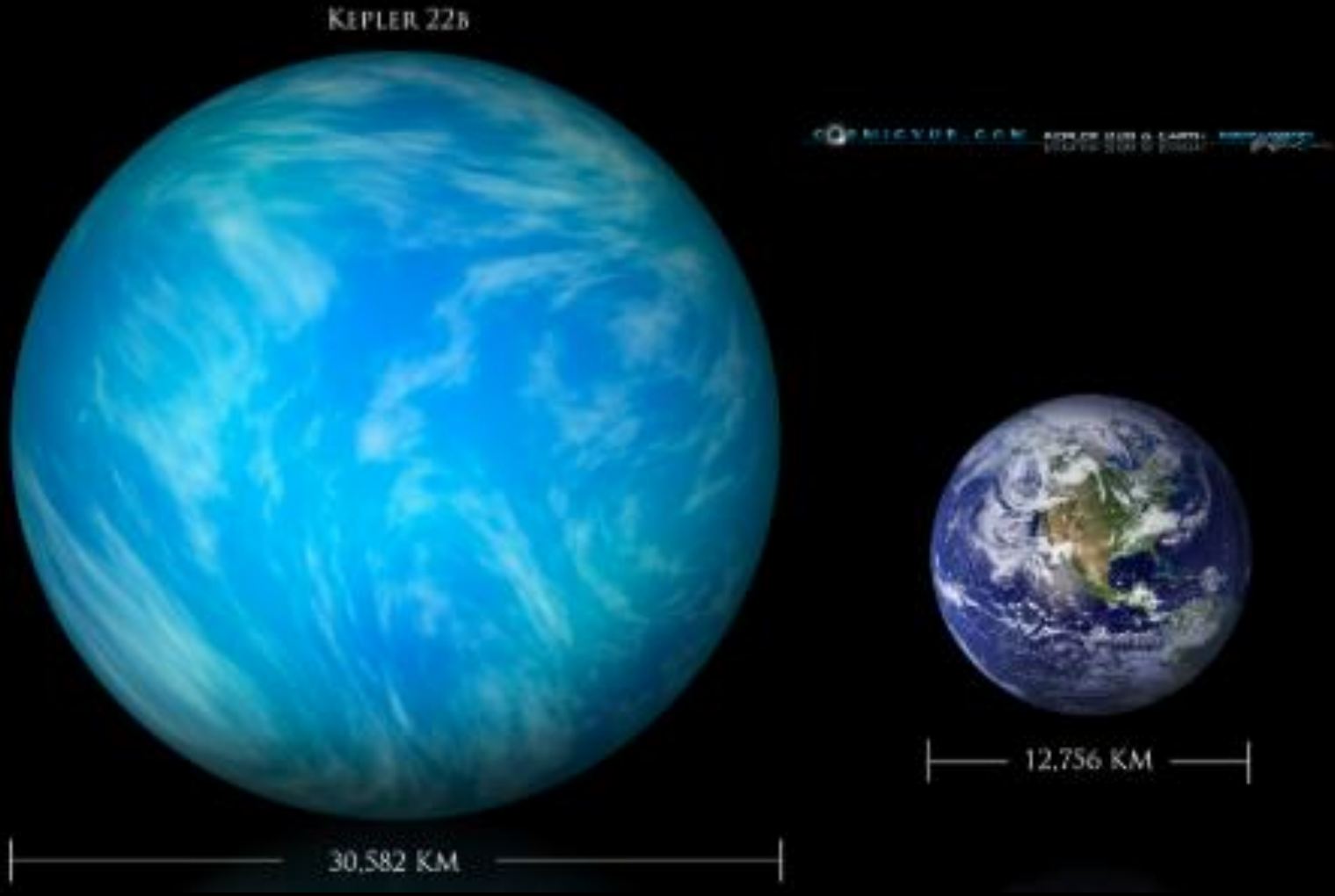
Planet Earth



The International Space station 400km above the South Island

Is there life beyond Earth?

TOI 700d- Earth sized exo-planet found in January 2020, it's well outside of our solar system orbiting a red dwarf star, in the Dorado constellation about 100 light years away



Kepler 22b-another exoplanet, 640 light years away, host star Kepler 22, planet's average temperature 22 degrees Celsius, 2.5 times bigger than our Earth.

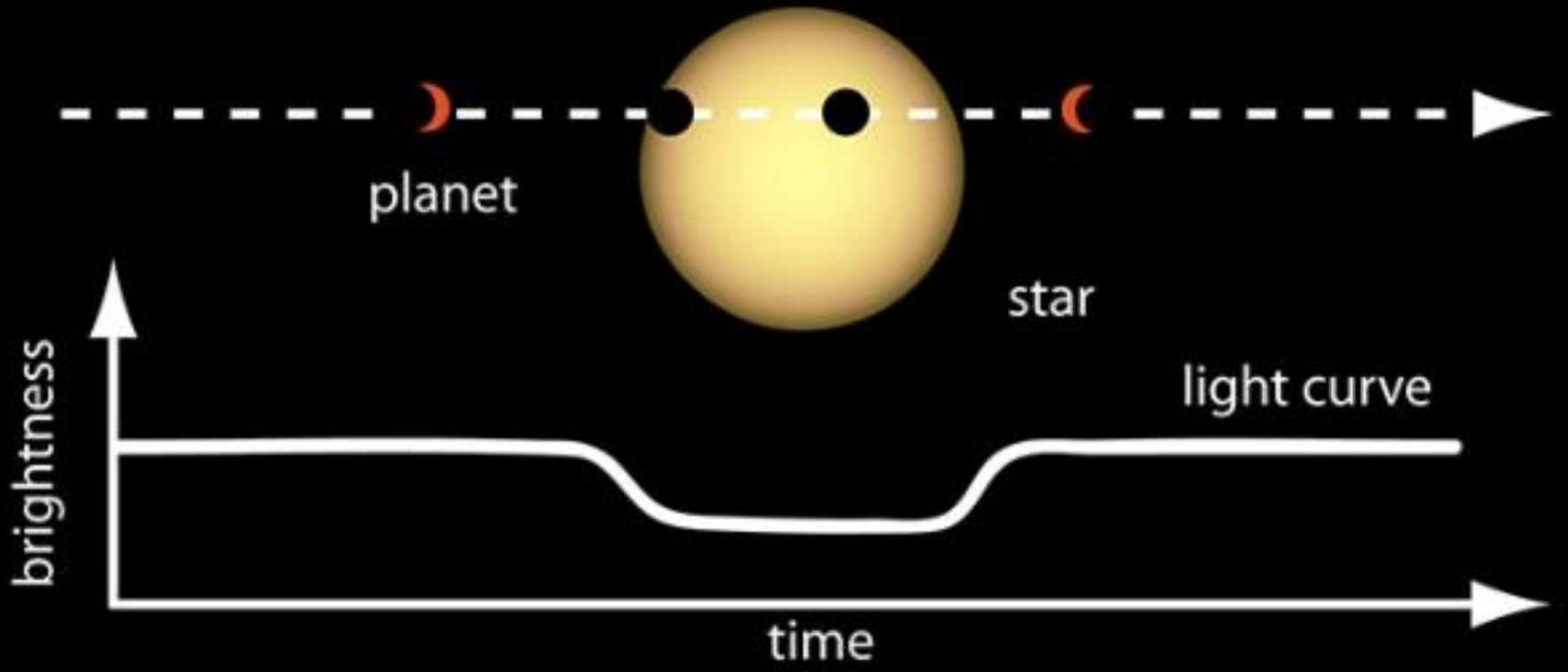
Could there be intelligent life on other planets?

Exoplanets around red dwarf stars

Could humans live on Kepler 452-b?

Kepler 452-b another exoplanet is 1800 light years away, orbiting a star like ours, it is nicknamed “Coruscant”, which is the name of the home of the Galactic Empire in the Star Wars films.

A Exo planet transiting a star



Space shuttle ready for launch, 1981-2011 space shuttle exploration duration, 135 launches

37m long


Atlantis
esa

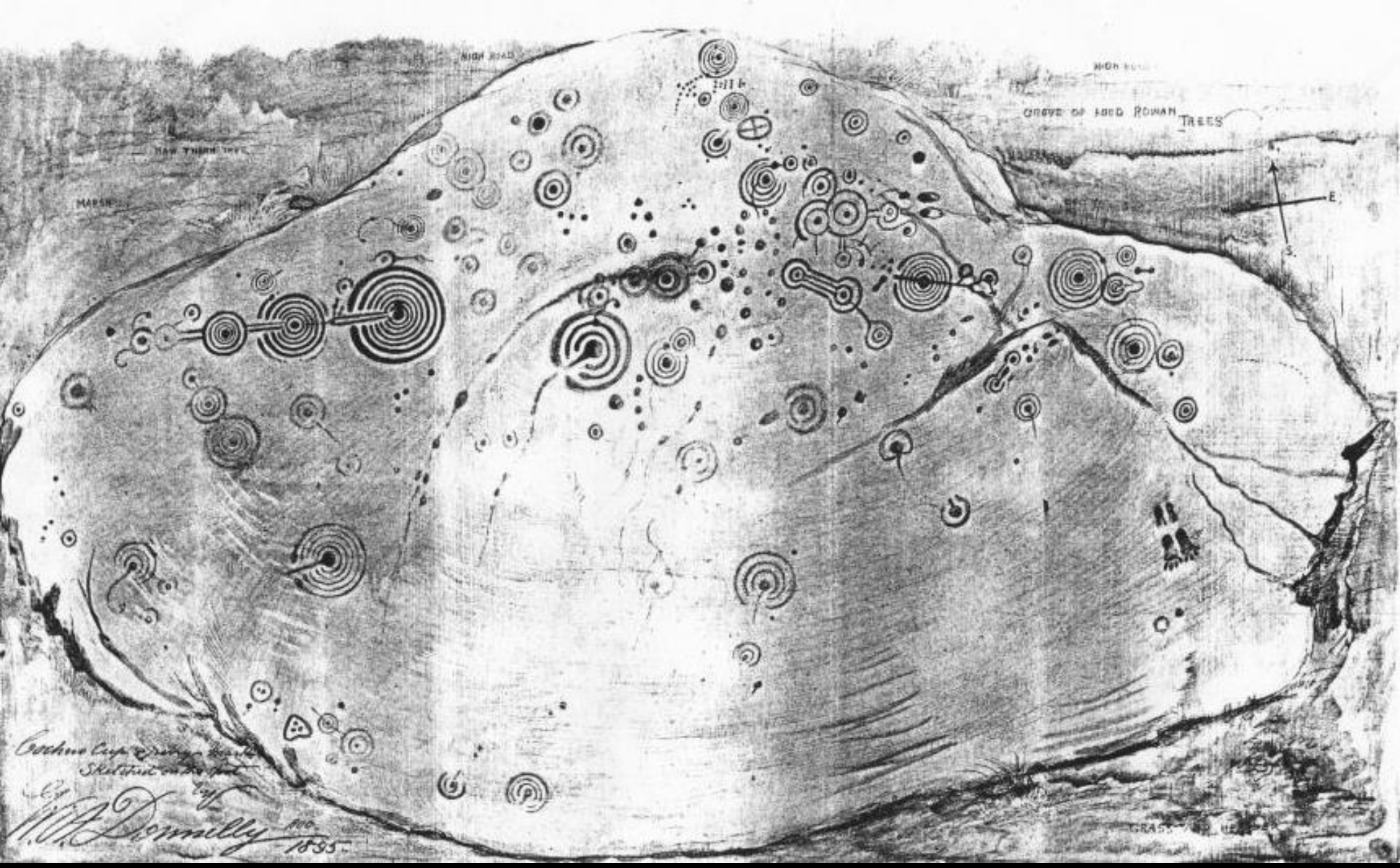
- *NASA's Space Launch System rocket, with twin Northrop Grumman solid rocket boosters, lifts off on the Artemis II mission, the first crewed Artemis program launch.* April 1, 2026

Artemis capsule (5mx 3m) re-entry speed is at 40,000km per hour or 11km per sec, altitude about 120km on entry

- Artemis II Orion spacecraft images of the lunar surface and planet Earth 6th April 2026

Space travel challenges

Vast distances, radiation protection, time travel, fuel, storing the fuel



The Cochno stone (13m x 7m), Faifley, West Dunbartonshire, Scotland,
Bronze age 3000 BC to 1200 BC

Archaeology meets cosmology- the Cochno stone (13m x 7m), Scotland.

My final thoughts and thank you for coming along tonight

I believe astrophysics, archeology, philosophy, even music merge together as realms to solve cosmic interactions, all can support the other in further understanding the universe, there are definitely parallels between them, the important thing for me is to keep an open mind.

The more I explore the atom and the universe, the more I sense that life is a cosmic dance, where atoms are patterns of energy, not solid spheres. There is nothing really solid about us.

Our own atoms come from an old star, we are the cosmic dance and perhaps the universe is a giant piano that plays the beautiful music.

Simon Taylor

Special thanks to

- Rachel Jenkins (Piano recital)
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- Peter Williams (Sound and IT Manager)

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