The Universe
Video Outline

Episode Title: ***Life and Death of a Star***
Length: :45

Typical galaxies have billions of stars
Milky Way ~200-400 billion

Pillars of Creation
"Stellar nursery"
Region of intense star formation
7000 LY away in Eagle Nebula
Hydrogen is the key component
Over time, gases can clump together by gravity

Recipe for a Star
Single nebulae can form up to thousands of stars
Typical Sun-like star requires an area 100x size of solar system
Nebulae typically very cold
As gravity crushes clumping nebulae, temps. rise and if rotating, form into a disk
Eventually, temps. May reach up to 2 million degrees - ***protostar*** forms
If core exceeds ~18 million degrees, fusion can begin
Massive release of energy in fusion process lights the star up and releases energy

Star's life is gravity vs. gas pressure
Gravity never "gives up" so star must find way to maintain balance
When balance is achieved, star is stable and found in the ***main sequence*** (of HR Diagram)
Much variety found on main sequence
Star color determined by temperature
Hotter the star, bluer the color

Red dwarfs
Proxima Centauri
Most common of all stars
Burn rather cool and are not very intrinsically bright

Blue Main Sequence
20x mass of sun
10K times brighter

Sun's life dictated by mass
High mass stars live short lives
Sometimes as little as a few million years
Low mass stars could live for 100s of billions
Once fuel supply ends, star will begin to die
Mass of star also dictates how the star will die
Massive stars explode
Small stars slowly fade away

Sun's Life Cycle
Probably 10 billion year life span
About half way through right now

Later Life
When a star runs out of hydrogen, helium is available but needs much higher temps. to continue fusion
The more complex an atom, the more difficult it is to get atoms close enough together to fuse
Usually the overall time to fuse helium is very short
Thin outer layer of star begins to evaporate away from star
Outer layer is ejected and creates a ***planetary nebula***

Death of Sun-Like Star
Star collapses as loss of fusion gives gravity the upper hand
As star is compressed, electrons in core creates pressure which supports star
Called ***electron degeneracy pressure***
Sustains the now earth-sized star as a white dwarf
Example: Sirius B

White Dwarfs
Very dense but very small
Final stage for sun-like star

Will shine for billions of years as remaining energy slowly drains off

Type Ia Supernovae

Binary systems that interact with each other can have big impact on star's life

Dwarf can steal matter from larger companion

If Dwarf reaches a certain size, it becomes unstable and explodes

Visible light of a supernova is less than 1% of total energy released

Type II Supernovae

Result of exploding massive star

Massive stars have enough temperature to fuse heavier elements far beyond smaller stars

Each time, temperatures get higher until iron core is reached

Fusion of iron requires more energy than it liberates

Iron core eventually becomes unstable and collapses

Split second rebound of core blows outer layers apart

Believed to be the source of the universe's heavier elements

Neutron Stars

Gravity fuses remaining core's electrons and protons into neutrons

Creates ***neutron stars***

As small as a few miles across

Amazingly dense

Teaspoon = billions of tons

Usually spin extremely fast

Creates massive magnetic fields

Pulsars

If polar magnetic field creates focused energy "beams" like a lighthouse

Black holes

Most extreme version of a post-supernova event

Gravitational field is so strong, light cannot even escape

Misconception - black holes suck everything up

Large objects can maintain orbits around black holes for millions of years

SN 2006GY

Fall 2006

Largest stellar explosion ever seen

240 million LY away

Total energy 100x strength of "normal" supernova

Star may have been 150-200x smore massive than star

Theory suggests early stars may have been fewer but much larger than current populations - may have seeded the early universe

Colliding Stars

Very difficult to see visually

Most computer simulations

Colliding neutron stars create waves of energy moving near the speed of light

White Dwarf vs Sun

Sun would be deformed by white dwarf

Shockwave from collision would destroy the sun

Perhaps 1 hour for white dwarf to penetrate sun before mutual destruction

Blue Stragglers

Found in ***globular clusters***

Very crowded region of stars where collisions may be much more common

Many stars moving in chaotic orbits around more or less central gravity source

Collisions every few thousand years

Older clusters had surprisingly young star components

How did young stars get in cluster?

Theory suggests they may be result of two main sequence stars merging within cluster

Resultant merged star is larger and brighter

Brown Dwarfs

Represent failed stars

Difficult to find due to low light levels and lack of fusion

Not enough mass for fusion

~80% mass of sun or less

May have surface features like an extra-large "Jupiter"

Several hundred known

Some have ***protoplanetary disks***