Star death

All stars eventually run out of fuel and die. Most fade away quietly, but the most massive stars self-destruct in a huge explosion that can outshine an entire galaxy.

Like Earth, stars generate the force of gravity, which squeezes their hot cores. The more matter a star has, the greater the force of gravity and the hotter and denser the core becomes. The way a star dies depends on how much matter it contains (its mass) and how powerfully its core is squeezed by gravity.

Stars make heat and light by the process of nuclear fusion: hydrogen atoms in the core crash together to form helium, releasing energy. In small stars, when hydrogen in the core runs out, the star's light slowly fades. But in more massive stars, the core is so hot and dense that fusion can spread beyond it, changing the star's appearance. The most massive stars are eventually overwhelmed by their own gravity, which crushes them so violently that they collapse into a pinprick to create a black hole.

Four ways to die

Stars can die in four different ways, all of which are shown on these pages. Our Sun, a typical star, will follow the central path, but not yet—it has enough fuel to keep shining for 5 billion years. When larger stars die, they turn hydrogen into heavier chemical elements such as carbon and oxygen, which are later recycled to form new stars and planets. All the atoms in your body were created this way.

5 billion tons—the weight of one teaspoonful of material from the core of a neutron star.

Stable star
Every young star goes through a stable phase in which it shines steadily.

Small stars
Stars with less than half the mass of the Sun fade away very slowly. Once the hydrogen in the core is used up, the star begins to feed off hydrogen in its atmosphere. But it doesn't generate enough gravity to use other elements as fuel, so it slowly shrinks to become a black dwarf. This will take far longer than the age of the Universe—up to a trillion years.

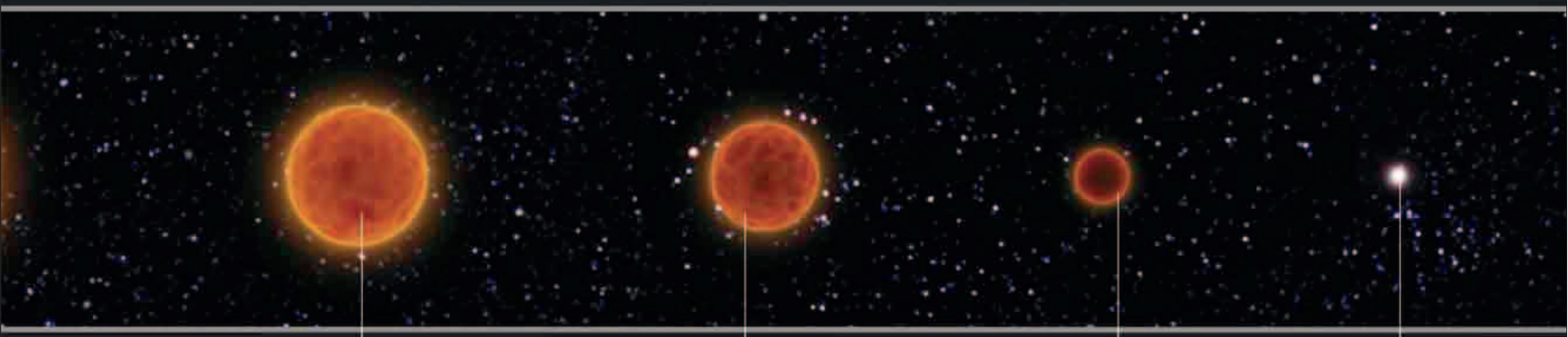
Star begins to shrink

Medium stars
When a Sunlike star has used up the hydrogen in its core, nuclear fusion spreads outside the core, making the star expand into a red giant. The core collapses until it is hot and dense enough to fuse helium, but eventually it runs out of helium too. Finally, it becomes a white dwarf, and its outer layers spread into space as a cloud of debris.

Star expands

Massive stars
Stars over eight times more massive than our Sun end their lives in strange and violent ways. The heat and pressure inside the core become so great that nuclear fusion can not only fuse hydrogen atoms together to form helium but can fuse helium and larger atoms to create elements such as carbon or oxygen. As this takes place, the star swells into the largest star of all: a supergiant.

Star expands

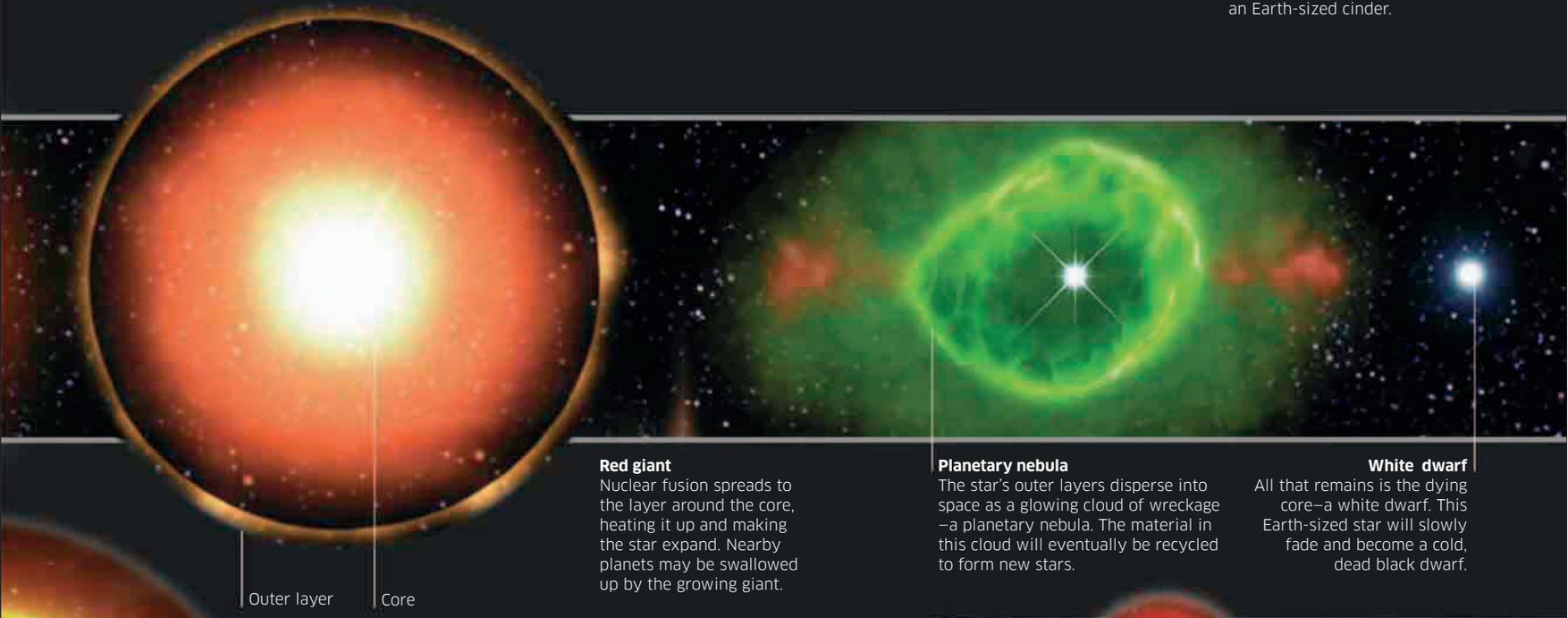


Light intensity fades as fuel runs out

Star continues to shrink and fade

Light becomes increasingly dim

Black dwarf
Finally, its fuel used up and its light extinguished, the star becomes a black dwarf–an Earth-sized cinder.



Outer layer

Core

Red giant
Nuclear fusion spreads to the layer around the core, heating it up and making the star expand. Nearby planets may be swallowed up by the growing giant.

Planetary nebula
The star's outer layers disperse into space as a glowing cloud of wreckage –a planetary nebula. The material in this cloud will eventually be recycled to form new stars.

White dwarf
All that remains is the dying core–a white dwarf. This Earth-sized star will slowly fade and become a cold, dead black dwarf.

Neutron star
Up to three times heavier than the Sun, yet just a few miles wide, neutron stars are unimaginably dense, fast-spinning stars.

Red supergiant
The star has grown into a supergiant. Nuclear fusion carries on inside the core, forcing atoms together to form heavier and heavier elements, until the star's core turns into iron. When this happens, the core no longer generates enough outward pressure to resist the crushing force of gravity, and the whole star suddenly collapses, causing a catastrophic explosion–a supernova.

Supernova
The star self-destructs in an explosion brighter than a billion suns. Its outer layers are blasted into space, but its massive core continues to collapse in on itself. What happens next depends on how massive the core is. A smaller core becomes a neutron star, but a massive core never stops collapsing. It shrinks until it's billions of times smaller than an atom and becomes a black hole.

Black hole
The force of gravity close to a black hole is so intense that nothing can escape from it–not even light. Anything falling inside is torn apart by gravity and then crushed into a point of infinite density.