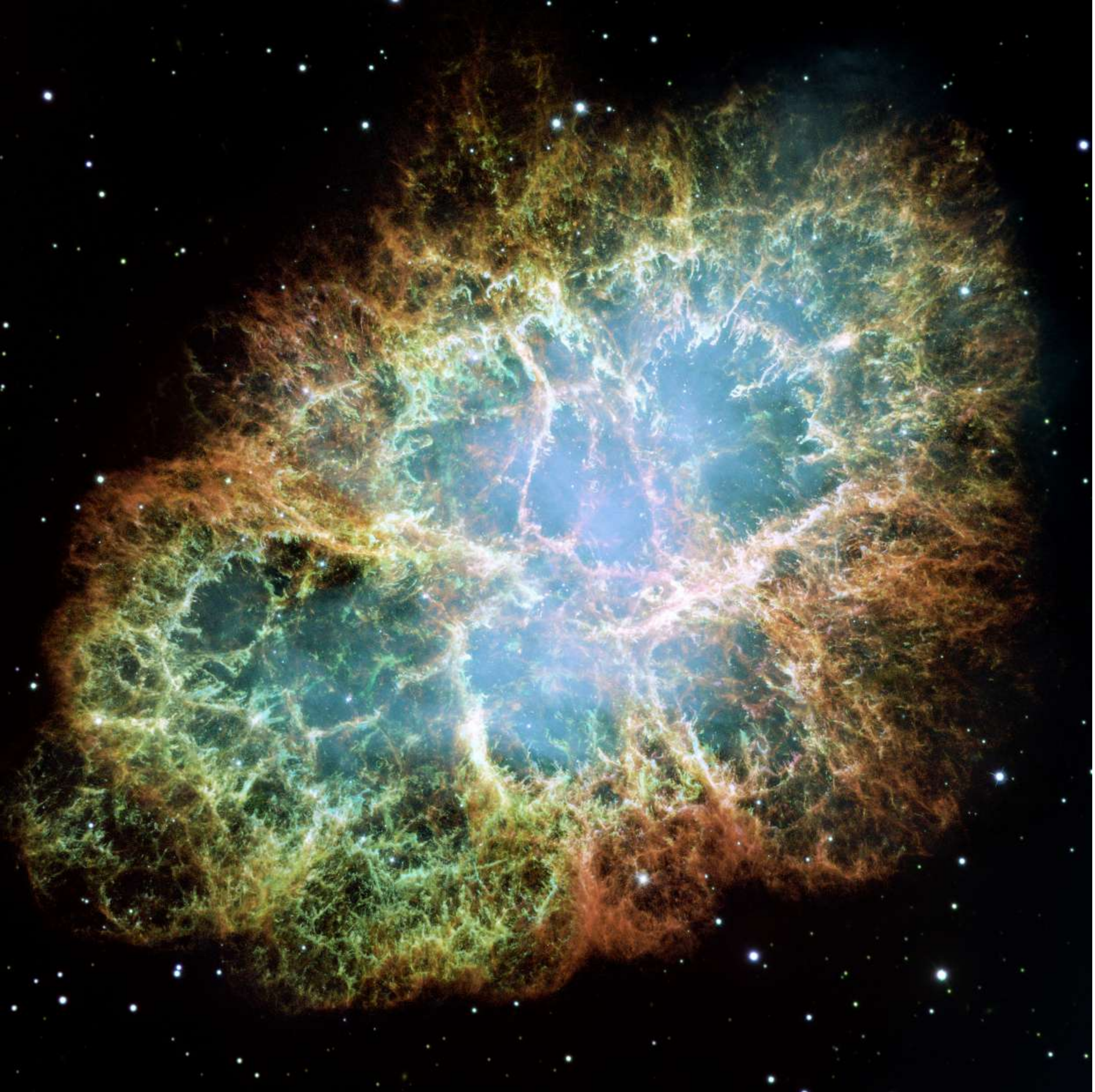

How To Blow Up A Star

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Rappahannock Astronomy Club

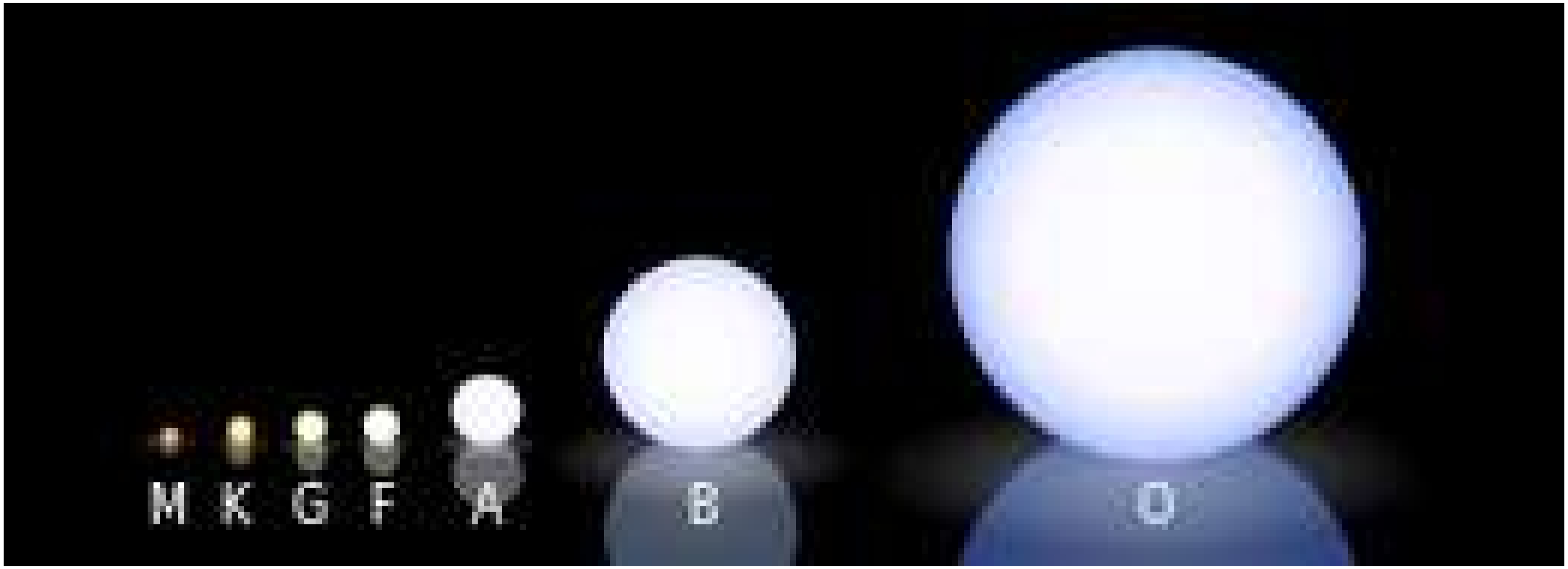
For Caledon State Park
2017-07-22

Crab Nebula, remnant of a star that blew up. We saw the explosion on July 4 1054.

Credit:NASA

It's All In The Mass

Stars are born with different birth weights. Some are low mass and others high mass.



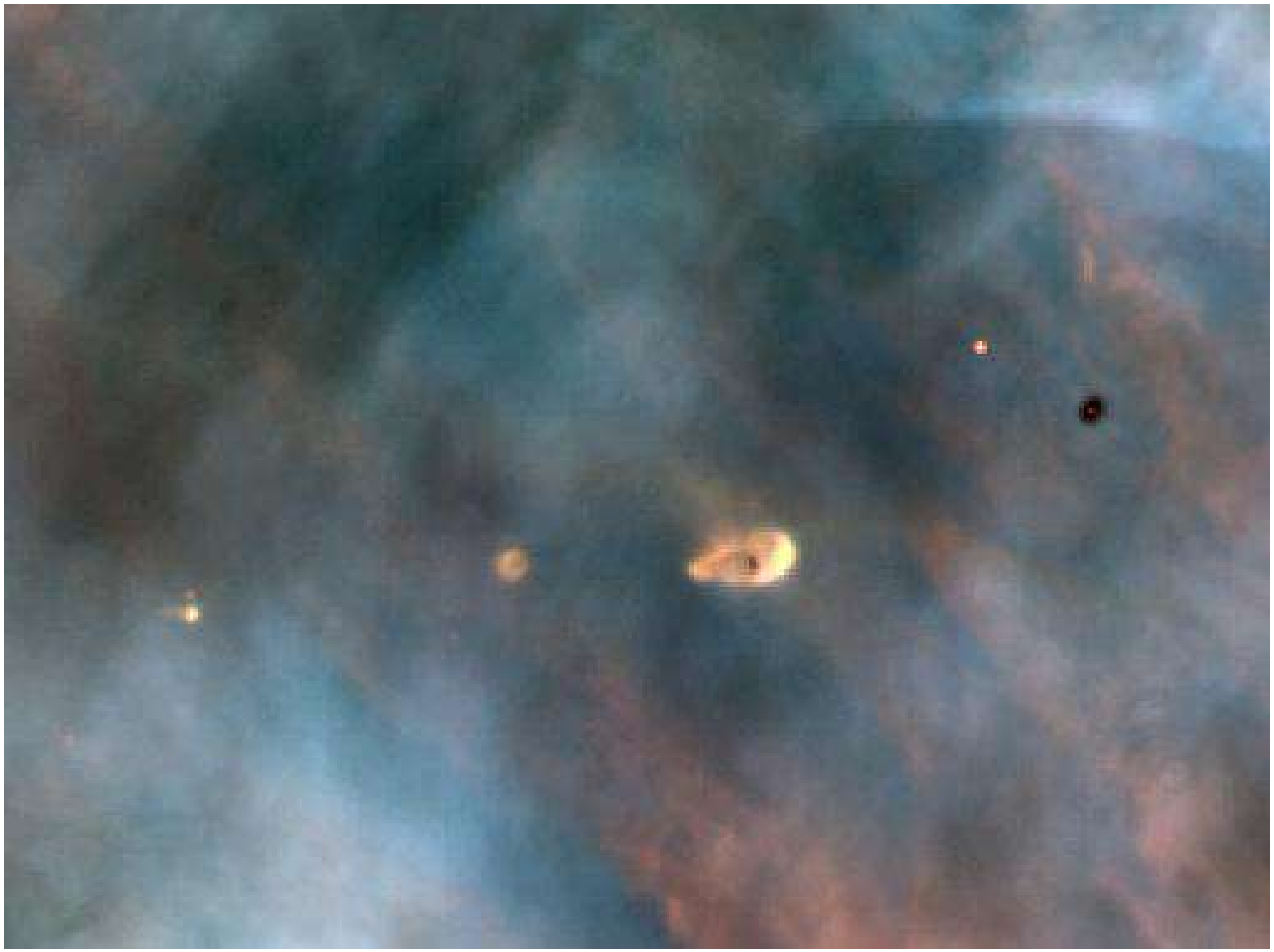
Low mass stars will never blow up. High mass stars can't help it. They will always blow up … eventually.

To Know How To Blow Up a Star, You Have To Know How To Make a Star

Credit: NASA

Start with the biggest cloud of gas and dust you can find.
High mass clouds produce high mass stars.

Let Gravity Collapse The Cloud



Credit: NASA

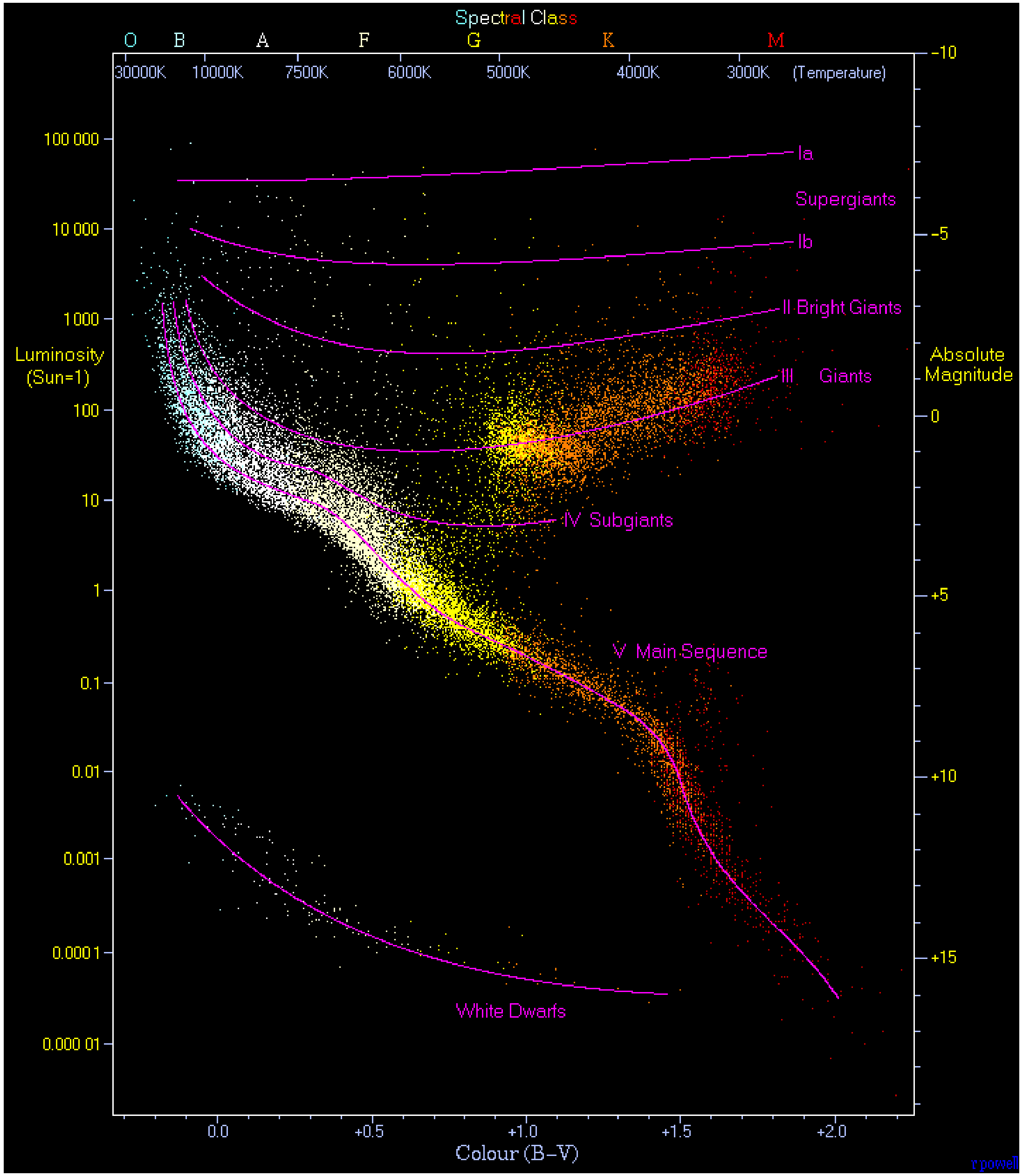
When clump of gas gets dense enough, the pressure and temperature inside get high enough for the hydrogen to fuse.

Newly Ignited Stars

Credit: NASA

Some of these new stars will blow up.

How to Predict if a Star will Blow Up

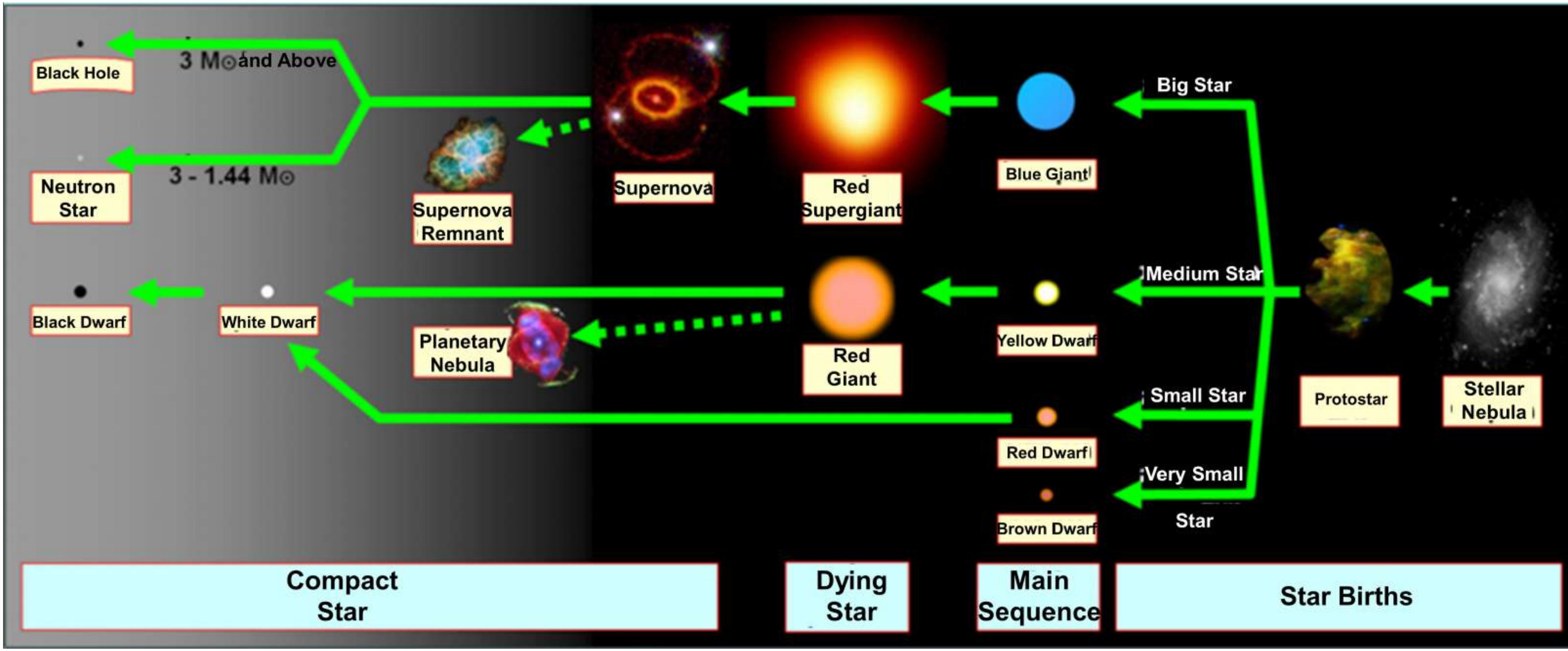


Hertzsprung-Russel Diagram

Credit: Wikimedia Commons

Measurements of thousands of stars shows that star color predicts brightness.
It turns out, both depend on mass. More massive stars fuse faster and hotter.

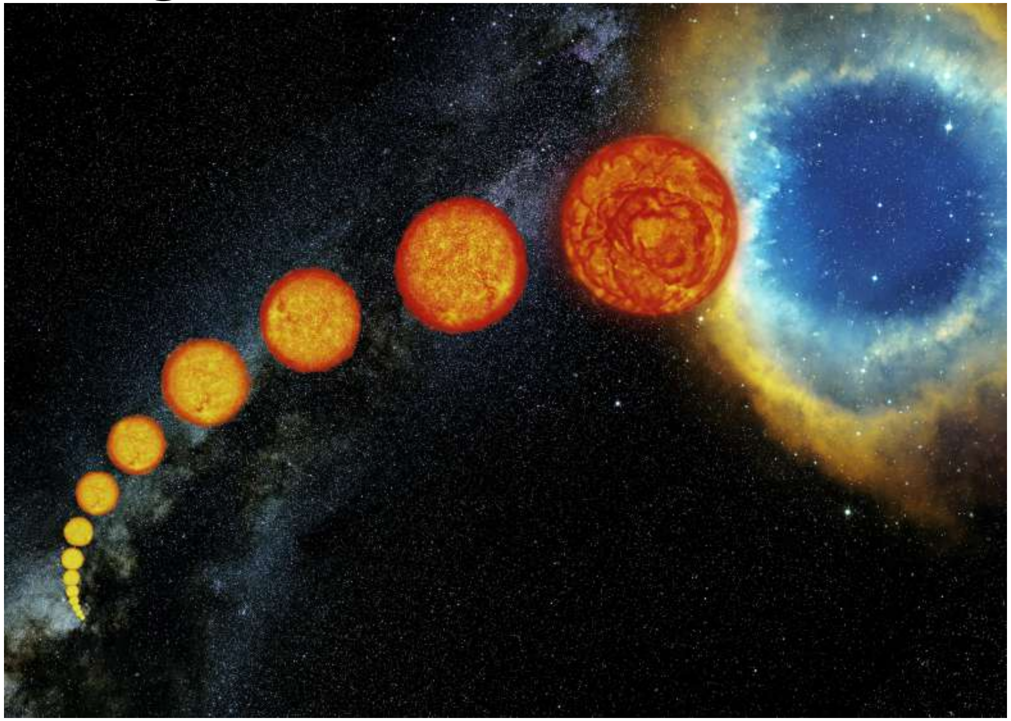
How Long Does it Take?



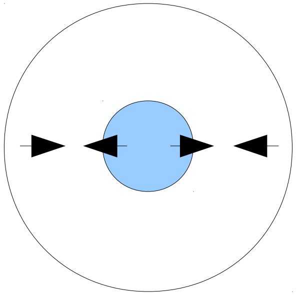
Credit: NASA

For a red dwarf, trillions of years
For our Sun, billions of years
For a blue giant, mere millions of years
The magic number: A star 1.44 times the mass of Sol will blow up.

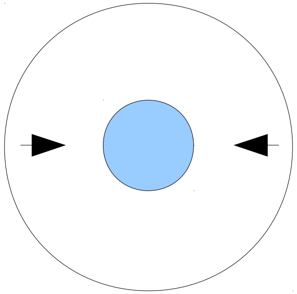
Boring Stars Don't Blow Up



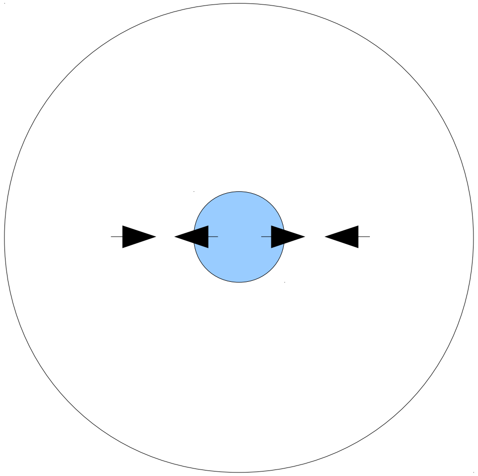
Credit:Wikimedia Commons



While a star is fusing hydrogen, energy created by fusion in the core balances gravity. This determines the star's size.



When all the hydrogen is consumed, fusion stops. Gravity makes the outer star fall onto the core.



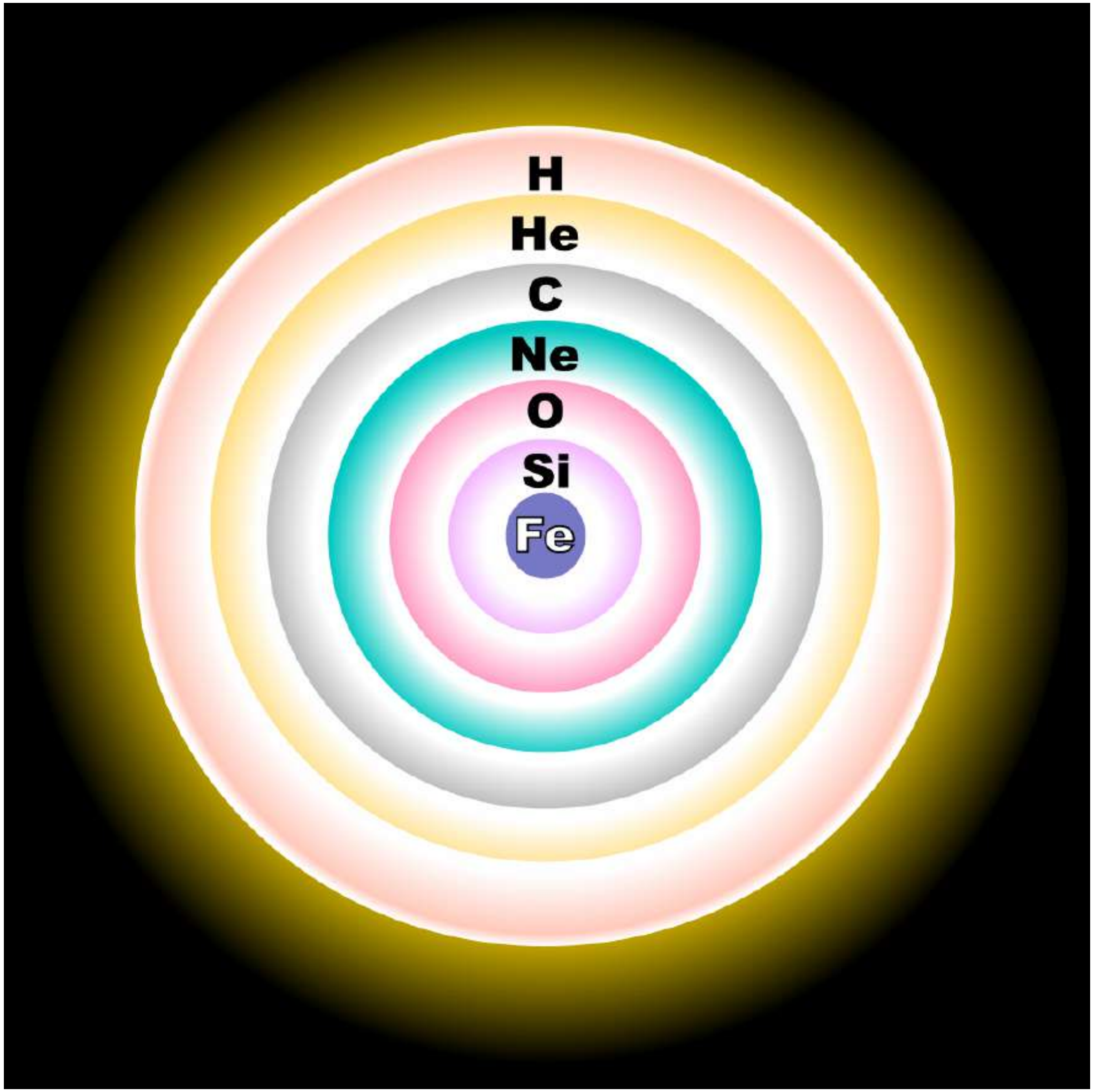
The increased pressure and heat may be enough to fuse hydrogen in outer layers. This creates more energy, so the star gets bigger and becomes a red giant.

After the Non-Explosion

Credit:Wikimedia Commons

The energy of igniting new fusion tends to blow the outer layers of the star off into space.
The red giant creates a planetary nebula around itself.
Later, the star finishes fusing all its hydrogen (sometimes also helium). Fusion stops.
The small, hot core of the star remains.
It has become a white dwarf.
This is the final state of stars like Sol.

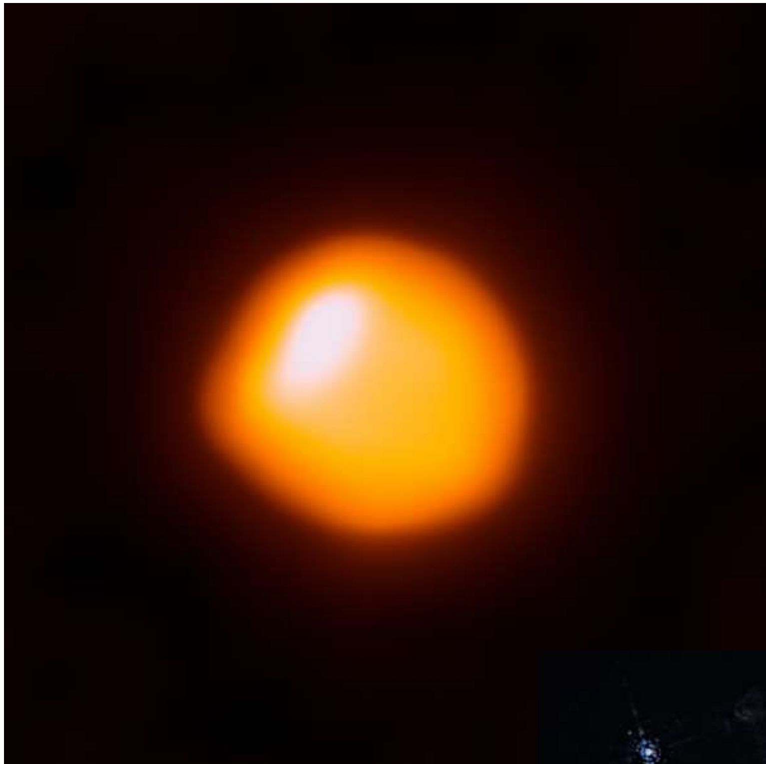
Why Must A Massive Star Blow Up?



Credit:Wikimedia Commons

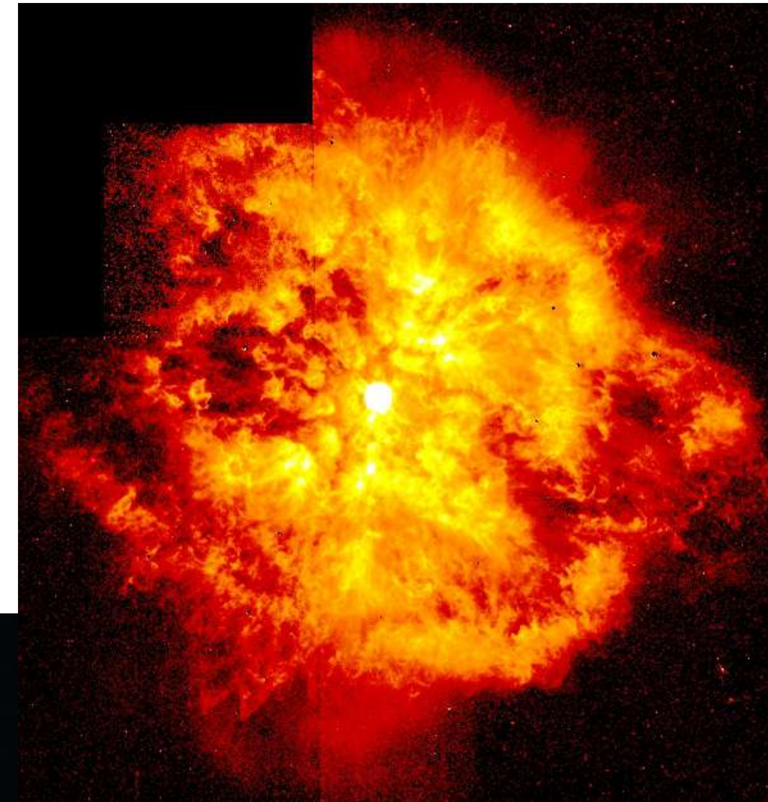
A massive star may start many new cycles of fusing heavier elements

Stars That May Blow Up Very Soon



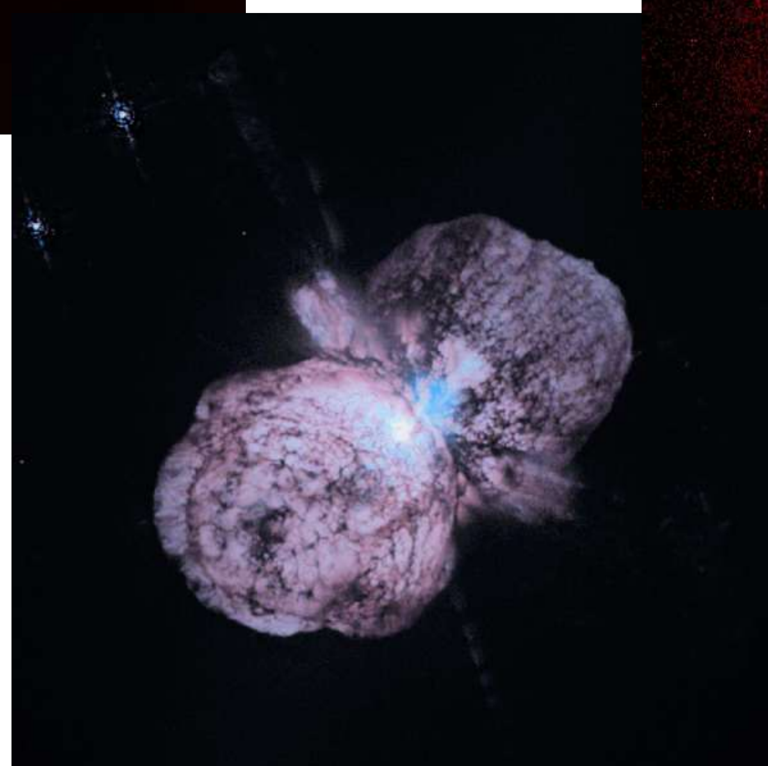
Credit:Wikimedia Commons

Betelgeuse. The bulge indicates uneven fusion. Likely supernova in 1My.



Credit:Wikimedia Commons

Wolf Rayet stars are a class that have already thrown off outer envelope. Likely supernova in 1My.



Credit:Wikimedia Commons

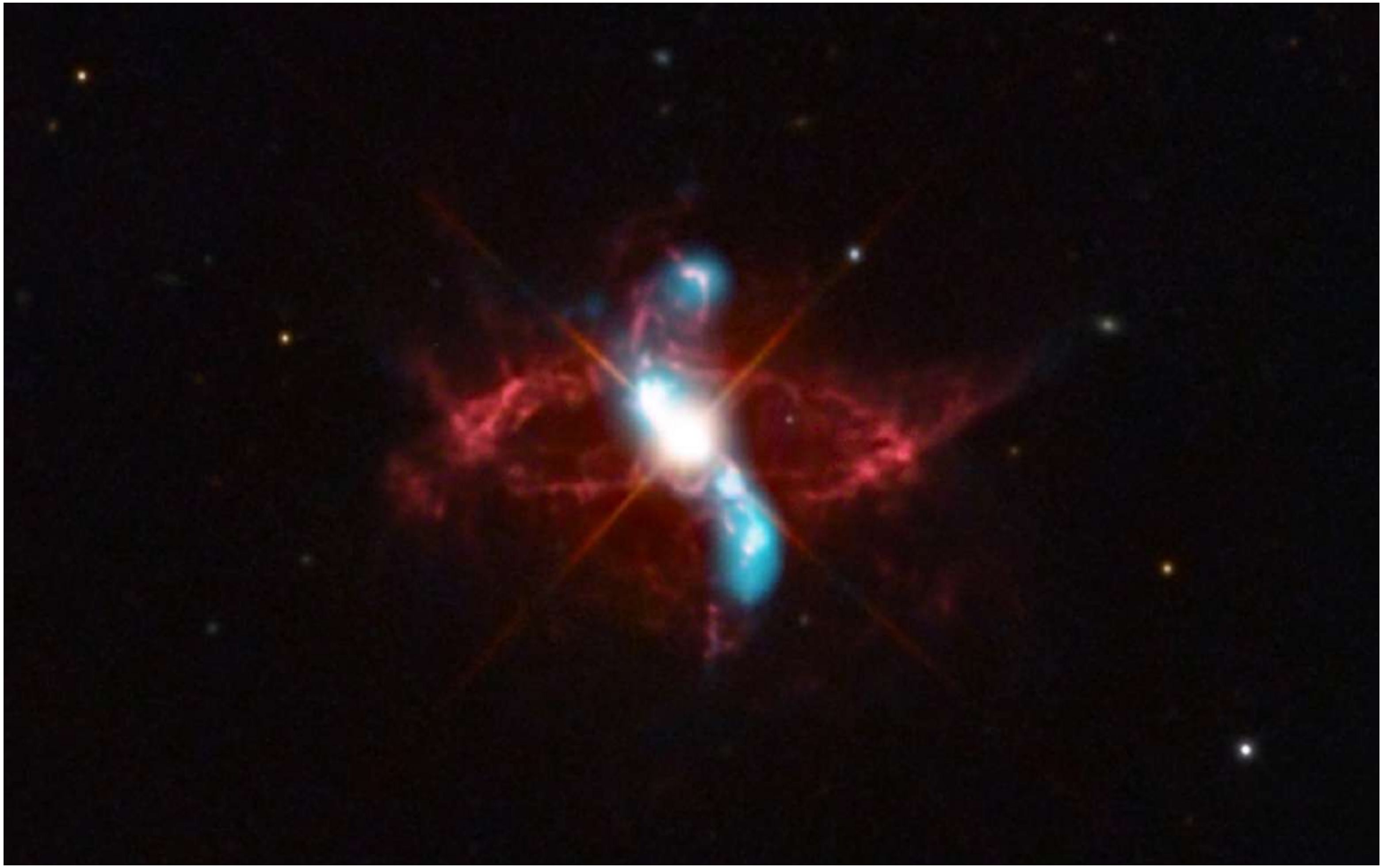
Eta Carina. Maybe supernova in 10ky.

Can We Speed Things Up?

Credit: Bryanston Pictures

Only by adding mass. Can we do this?

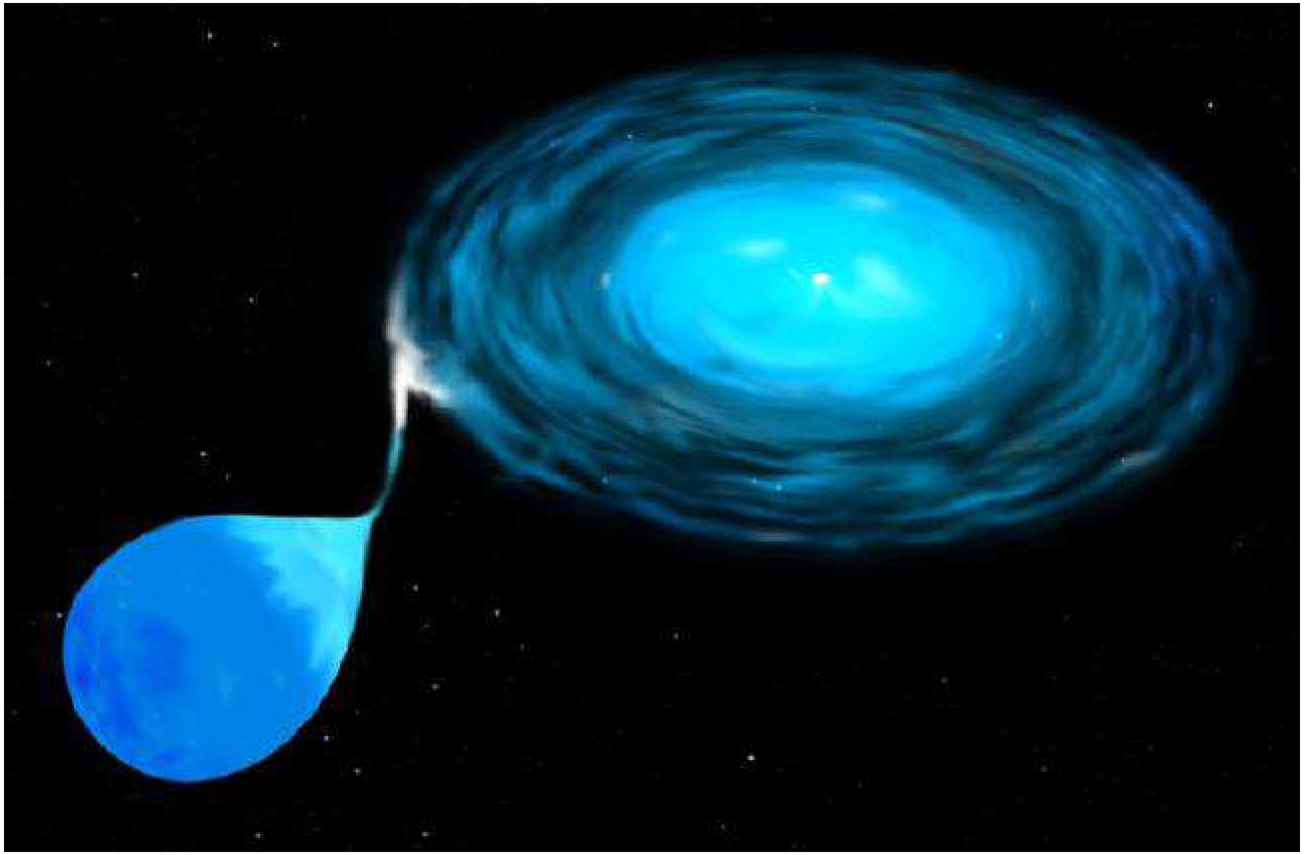
How to Add Mass to a Star



Credit:NASA

Stars are usually born in pairs, as binary stars.
But these are rarely identical twins.
    One will be more massive than the other.
When both are below the magic number, both will evolve into white dwarfs.
But one will get there first.
Sometimes the two stars are close enough that gas from the still-evolving star can fall onto the white dwarf.
    Especially likely after the still-evolving star becomes a red giant.
This means the white dwarf gains mass.

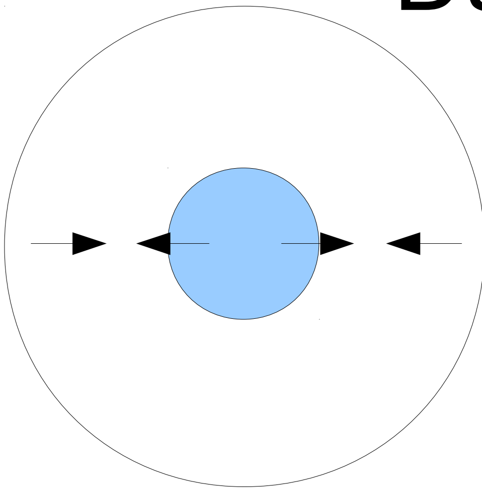
What Happens When You Add Mass to a Star



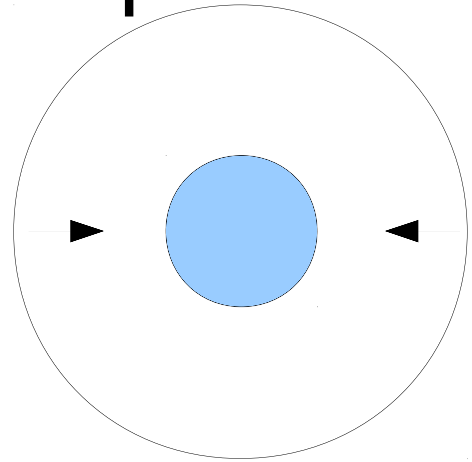
Credit:NASA

This sibling rivalry can cause many novas on the way to a supernova.
But eventually, if the white dwarf gains enough mass, it must blow up.

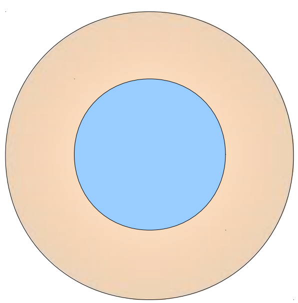
During the Explosion



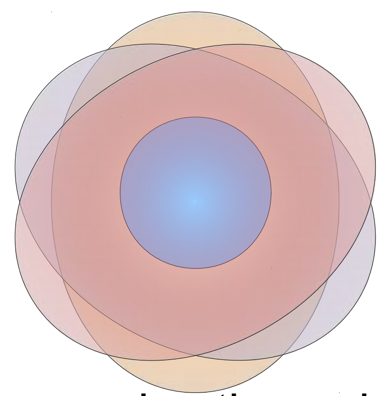
While the star is fusing, energy created by fusion in its core balances the force of its outer layers trying under gravity to fall onto the core.



When the star can fuse no more, its outer layers fall onto the core. Pressure and density increase.

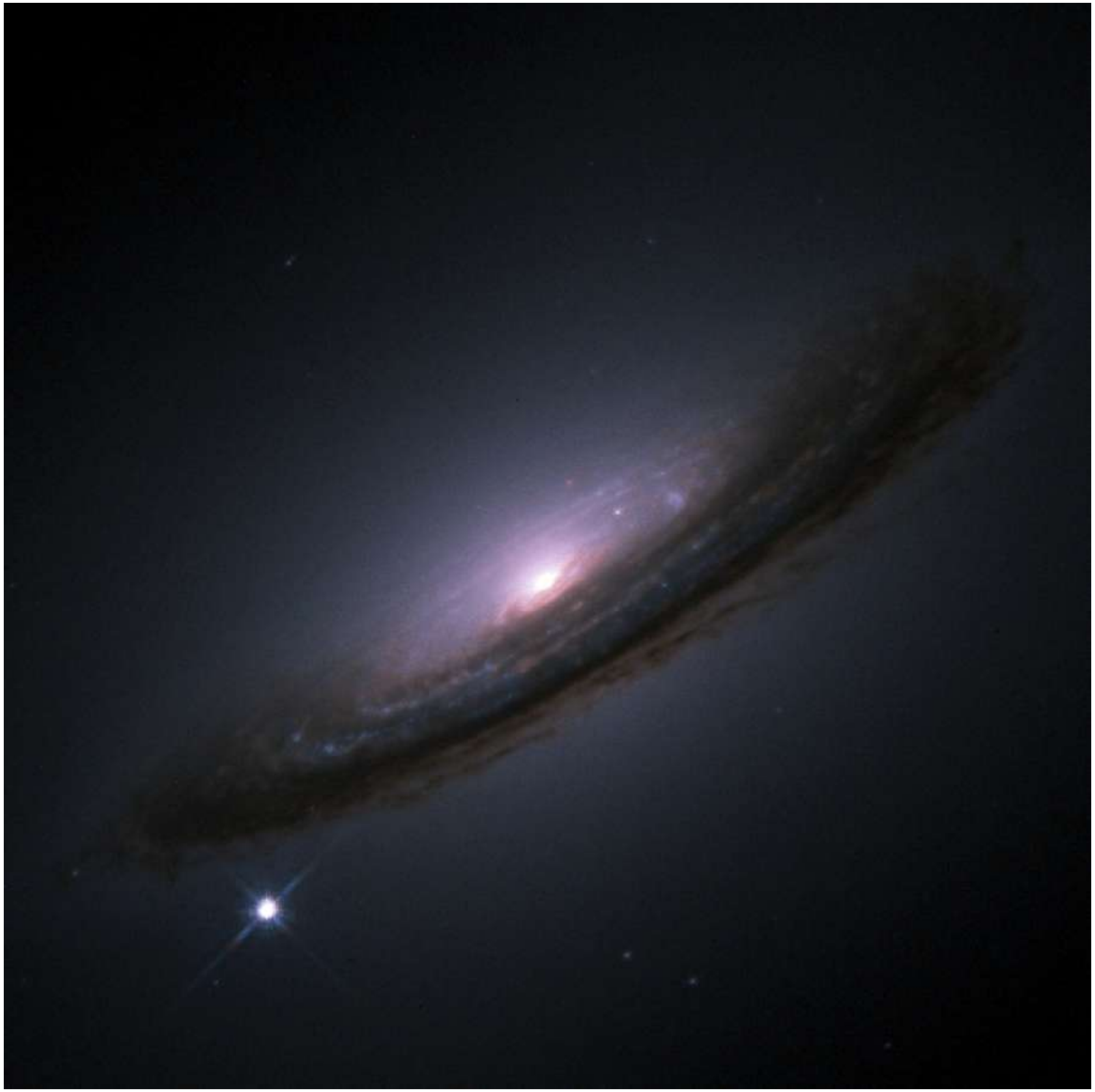


When the core can get no more dense, the infalling layers bounce off the core.



The infalling and outbouncing matter compress each other to temperatures and pressures not seen at any other time.
All of this matter undergoes rapid fusion.
The star blows up.

Hypernova: Blowing Up Even Bigger

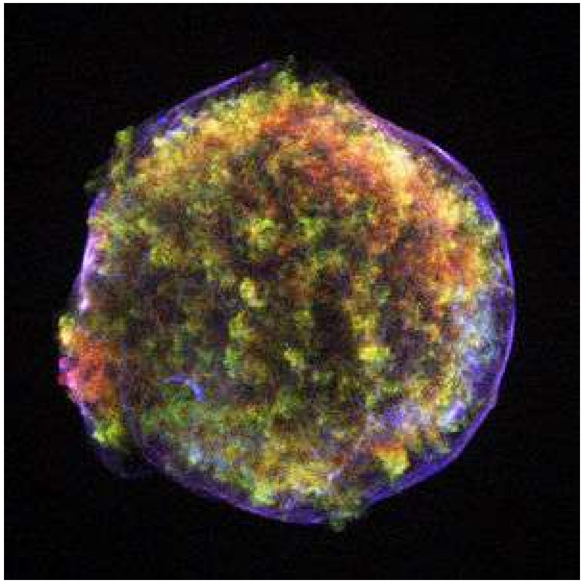


Credit:NASA

After the Explosion

Credit:Wikimedia Commons

Supernovas Make History



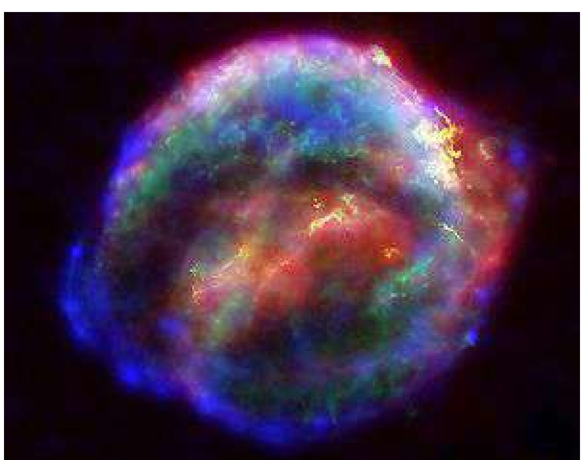
Credit: Wikimedia Commons

Greek model: Stars are unchanging.

Disproved by two new stars:

Tycho's Star 1572. As bright as Venus (mag -4), visible in daytime. Visible for 11 months. 8,000 light years away.

(I am lobbying to rename it Digges' Star.)



Credit: Wikimedia Commons

Kepler's Star 1607. Brighter than any star (mag -2). Visible in daytime for 3 weeks, at night for 18 months, though 20,000 light years away.

Extremely unusual to have two visible supernovae in 35 years.

There has not been another this bright since these two.

We are overdue for a bright one.

Keep looking up!