How (and Why) Stars Die

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Twinkle, twinkle, little star
How I wonder what you are ...

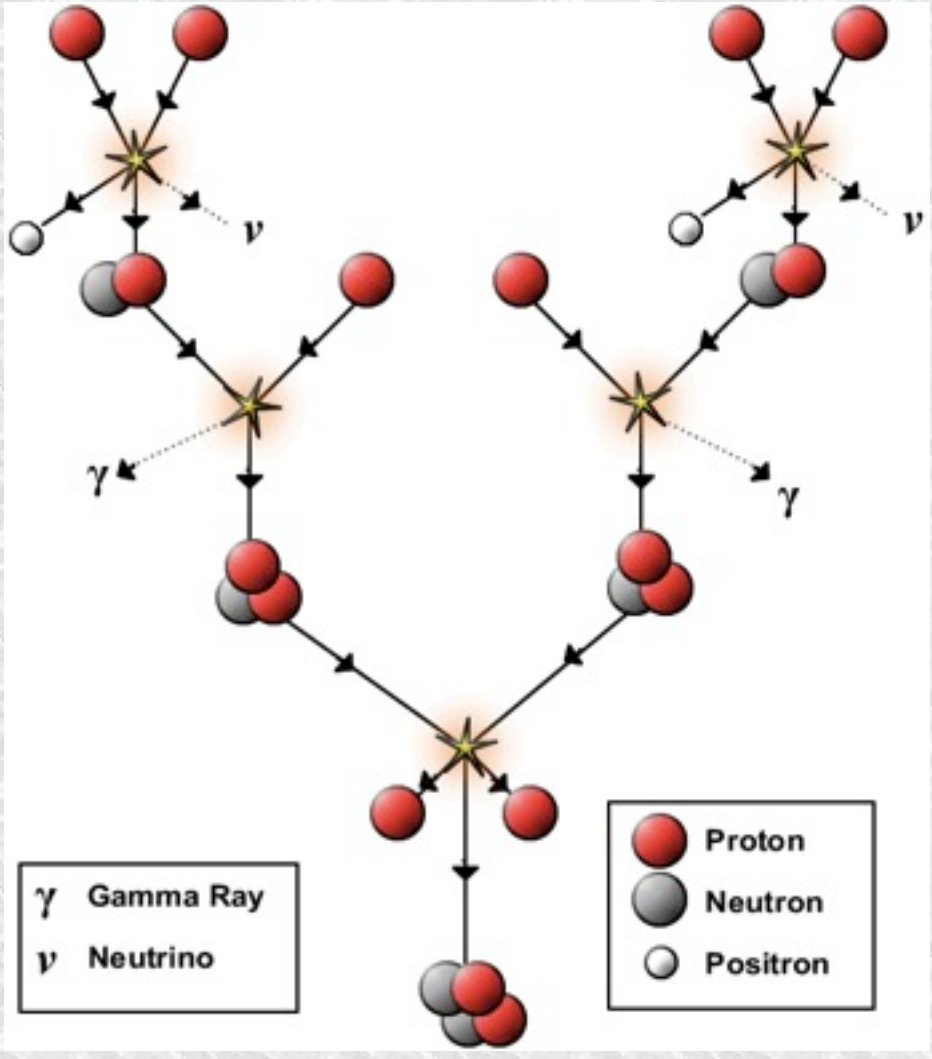
Stars Are Distant Suns!

- The sun is a million times bigger than the earth
- Stars shine by producing energy; moons and planets shine by reflected light
- Stars produce energy in their hot core, where the temperature is 15,000,000 degrees!

The stars are born in nebulas: clouds of gas and dust in space

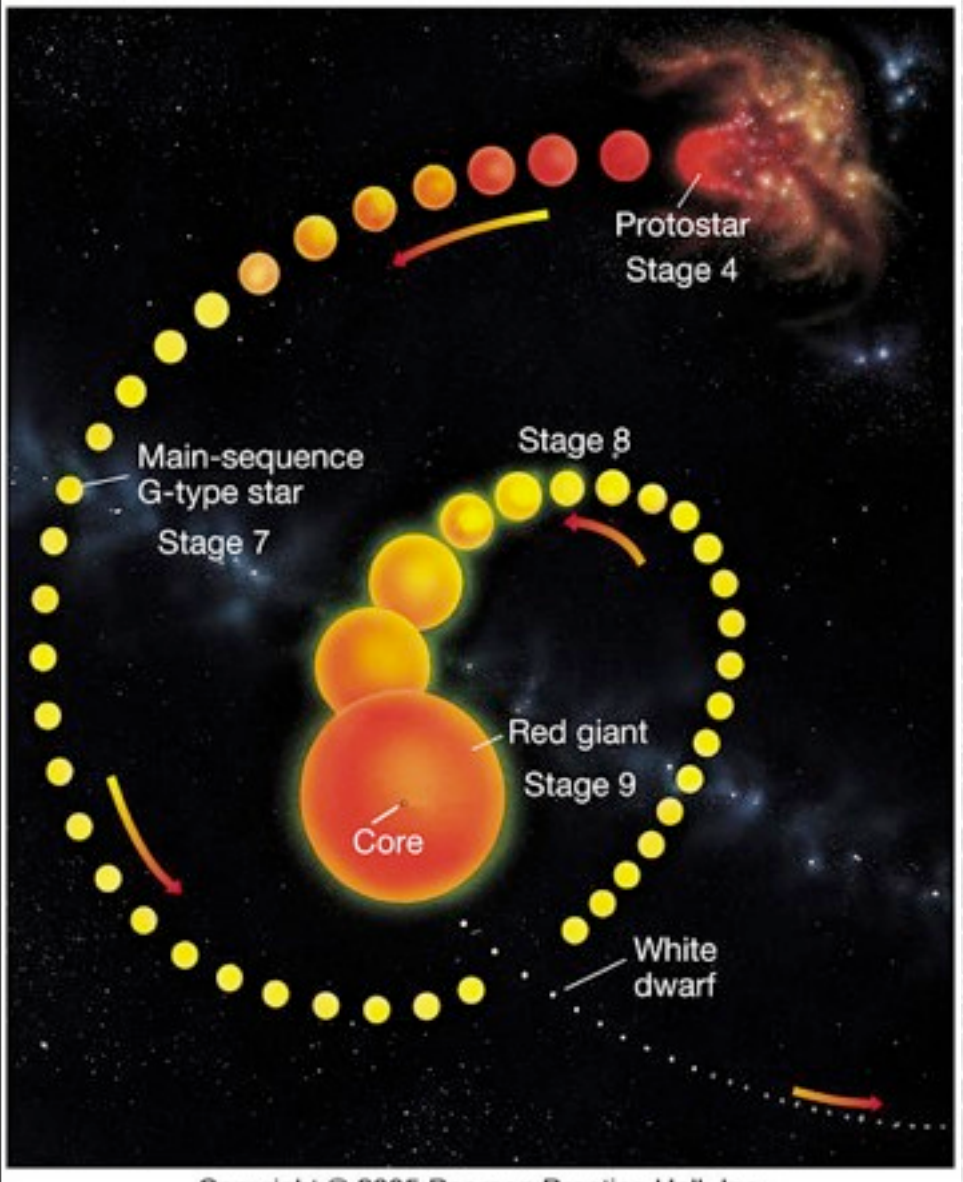
- Nebulas, like the Orion Nebula which you can see with binoculars, are clouds of gas and dust in space
- The gas and dust comes from the birth of the universe, and also from dying stars

The stars make energy by nuclear fusion of hydrogen



- The stars are made of ¾ hydrogen and ¼ helium
- In their hot, dense cores, the hydrogen fuses into helium: “thermonuclear fusion”
- If we could harness this process on earth, it would solve many of our energy problems!

Stars have long lifetimes!



- The sun's power is 400 trillion, trillion Watts
- Still, it has enough fuel to last for 10 billion years
- Most stars have even longer lifetimes – trillions of years
- Only rare, more massive stars have shorter lifetimes – millions of years

But the stars eventually run out of fuel

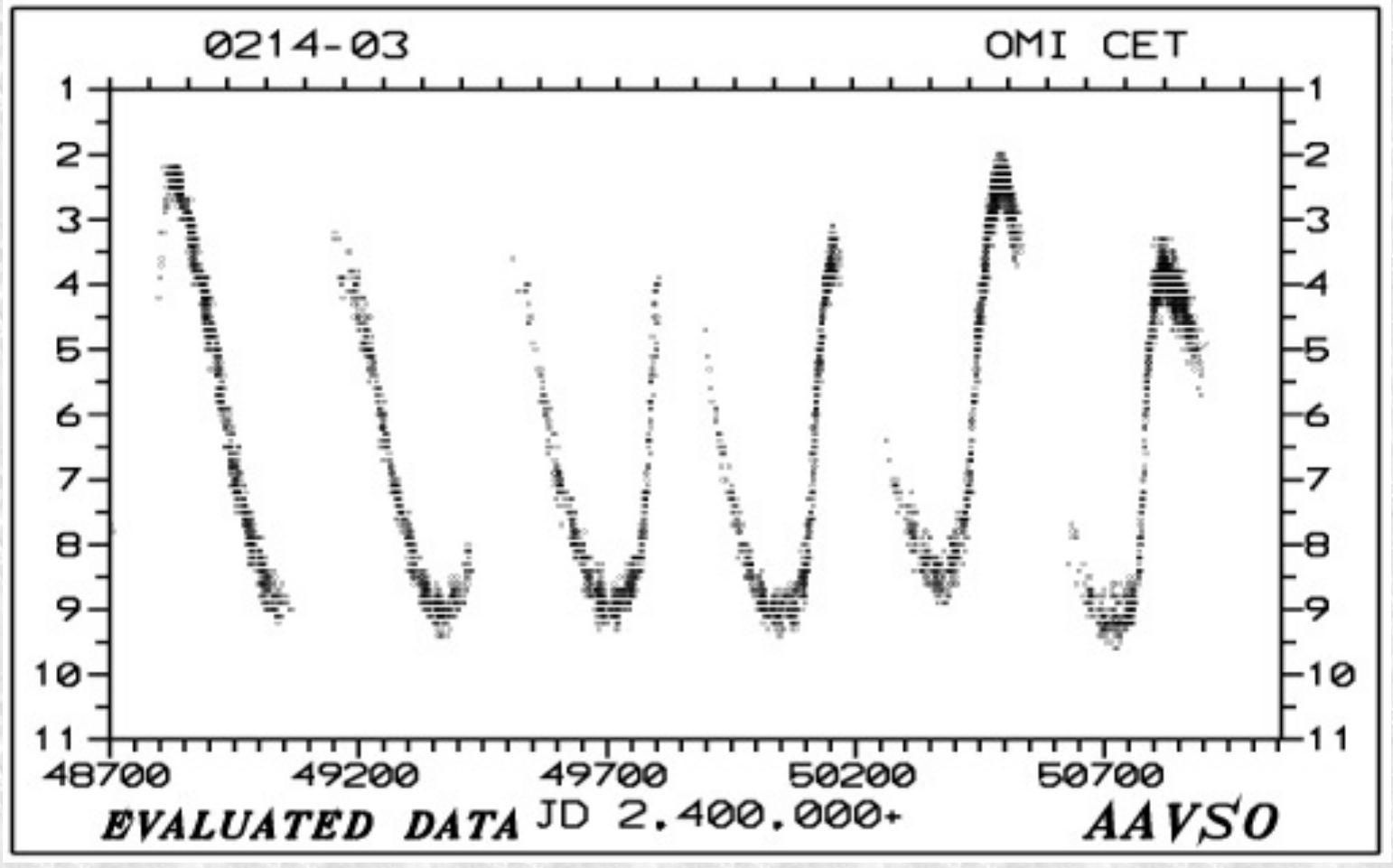
- Every energy supply runs out eventually
- The stars run out of energy when all of the hydrogen in their hot core is changed into helium
- The core shrinks, to try and squeeze some energy out of the helium
- The rest of the star swells into a red giant

The red giant begins to pulse

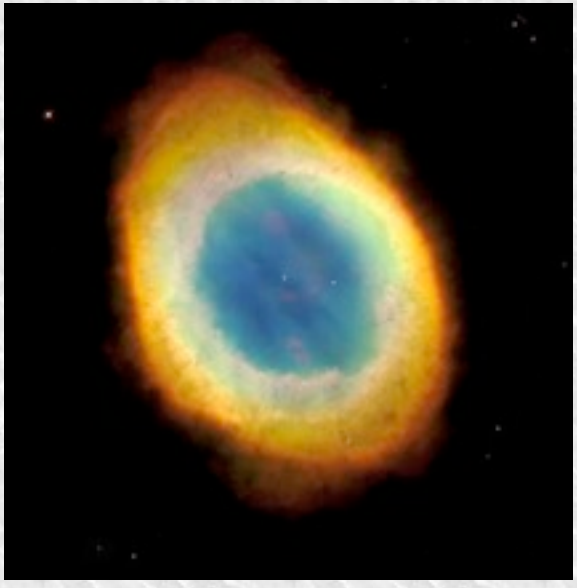
- The red giant swells, cools and brightens, swallowing the inner planets
- The outer layers become unstable
- They begin to pulse, in and out, every few weeks or months
- The pulsing drives off the outer layers into space, forming a planetary nebula

Mira Ceti is a Pulsing Red Giant

Every 330 days, it brightens and fades as it expands and contracts. These measurements were made by skilled amateur astronomers



Dying Suns – Planetary Nebulas



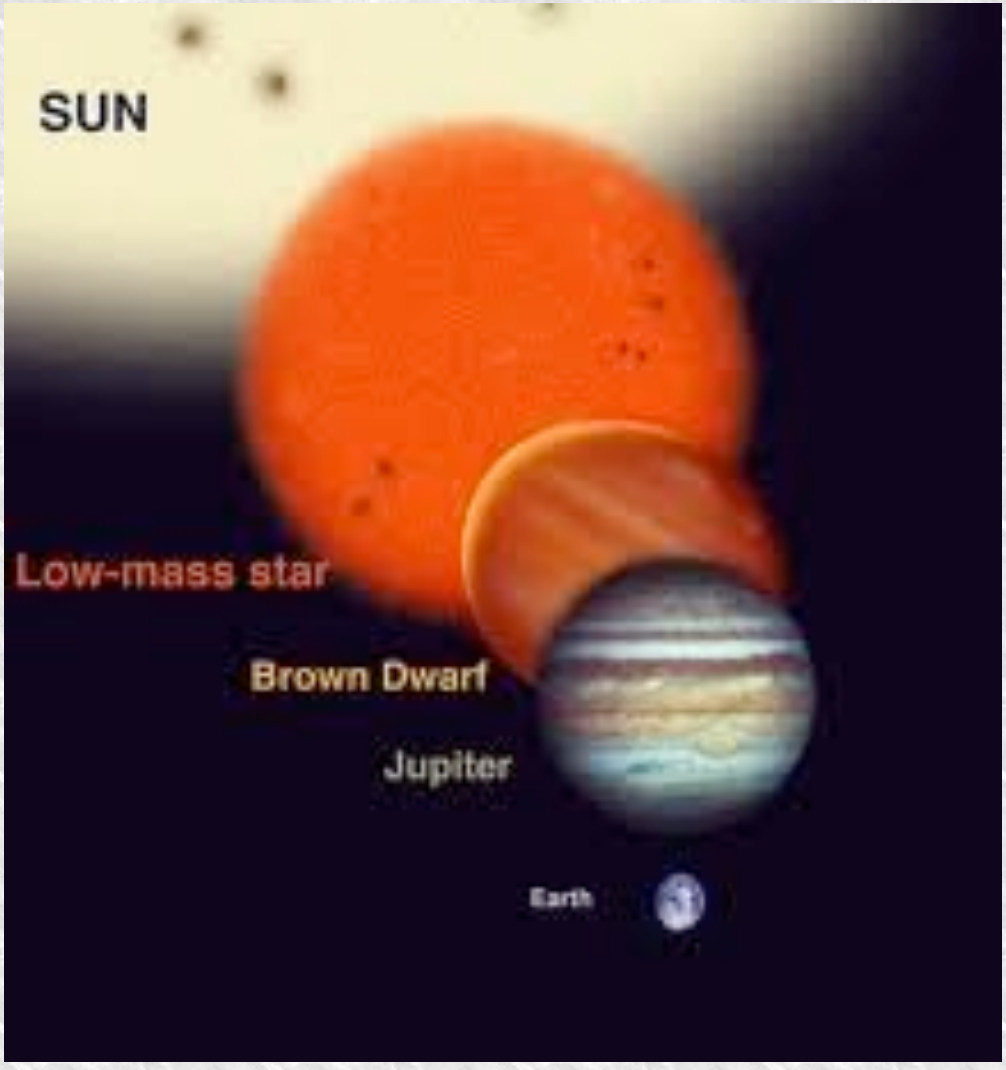
White Dwarfs

- A white dwarf is the shrunken corpse of a normal star like the sun
- It has the mass of a star, in the volume of the earth
- It's density is a million times that of water
- It has no energy; it just cools off like a cinder in a fire

Sirius B: A Nearby White Dwarf

- Sirius is the brightest star in the night sky
- It is actually a pair of stars, orbiting each other
- One (Sirius A) is a normal star; the other (Sirius B) is a white dwarf
- It is the remains of a star that has already lived and died

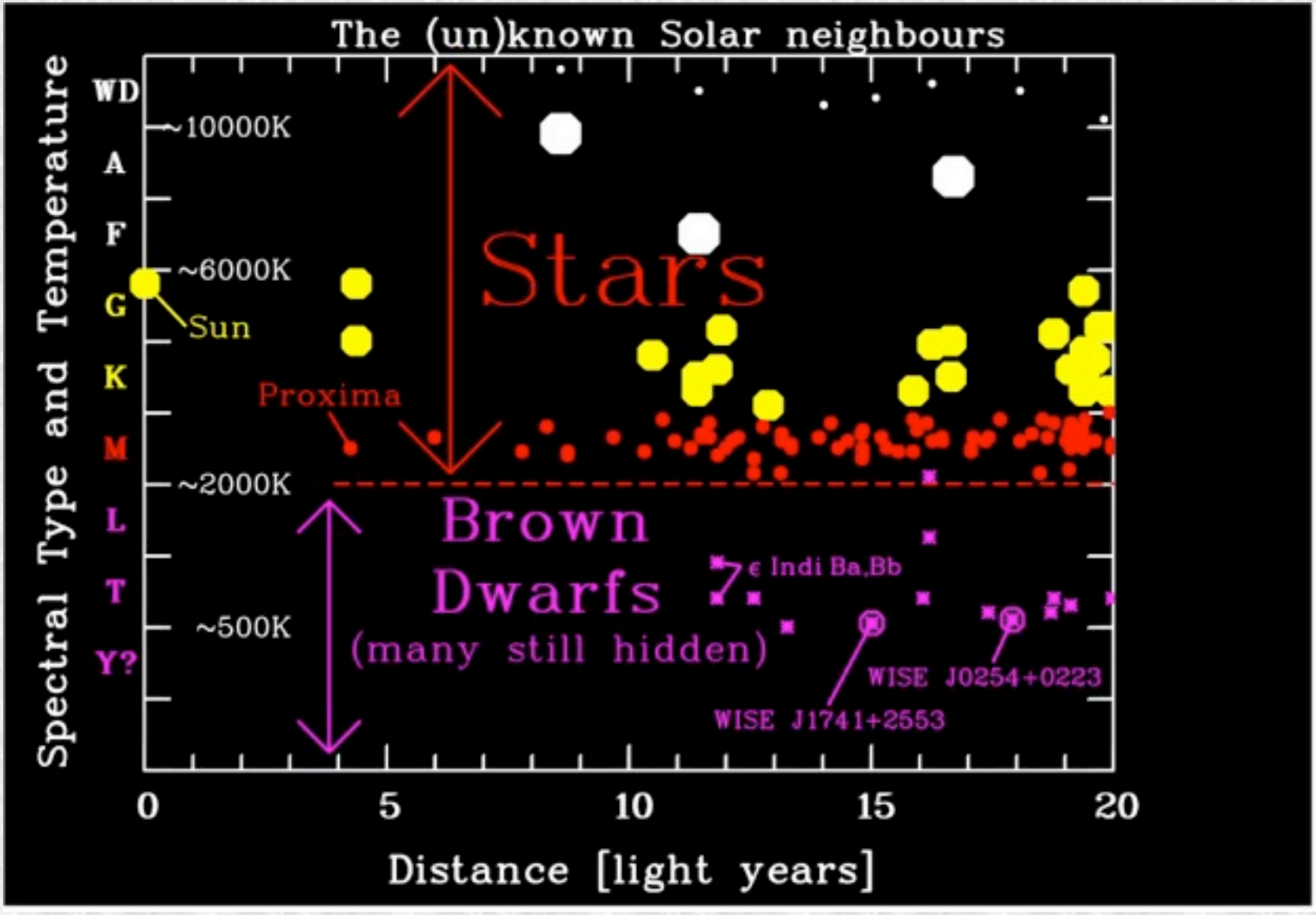
The sun is not an average star!



- You may have learned that the sun is an average star
- It's not; it's bigger and more powerful than 90% of other stars
- Most stars are like the “low mass” star at left
- Massive stars are very rare!

The sun is not an “average” star!

Smaller stars are common; larger stars are rare



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When massive stars run out of fuel

- Rare, massive stars fuse hydrogen into helium, carbon, oxygen, and elements as heavy as iron
- When they run out of fuel, their cores collapse violently under their own weight
- The gravitational energy release explodes the star: a supernova

Brightest Supernova in 400 Years!

This supernova was discovered by University of Toronto astronomer Ian Shelton on February 23-24, 1987 – 25 years ago!

Supernova remnants

- The supernova remnant is blasted into space at thousands of km/sec!
- This material has been enriched in the elements which were created in the star by nuclear fusion
- The material forms new nebulas from which new stars and planets and life are made
- You are starstuff!

Neutron Stars!

- The core of a rare, massive star collapses under its own weight until it is a ball of neutrons – a neutron star
- Its density is a million tonnes per cm^3
- It can spin faster than a kitchen blender!
- It emits pulses of radiation as it spins; it is a pulsar

When a *very* large star runs out of fuel

- One star in billions is so massive that, when it runs out of fuel, and collapses under its own weight, its core becomes a black hole
- Its density is so great that its gravity is so strong that nothing can escape from it – not even light

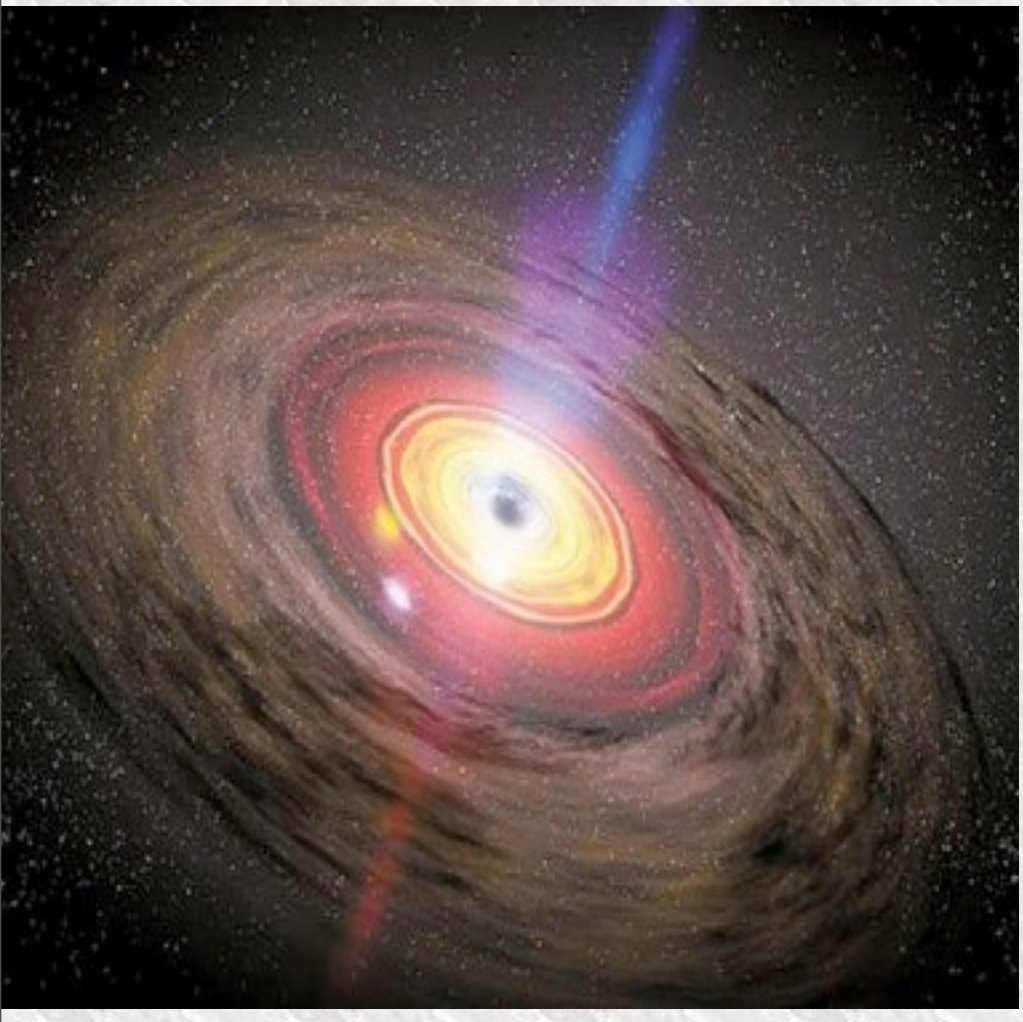
How the first black hole was discovered

- By University of Toronto astronomer Tom Bolton at the Dunlap Observatory in Richmond Hill ON
- By the black hole's pull on a normal star going around it
- And from X-rays produced as gas falls into the black hole

Myths about black holes

- You can see a black hole. No, light can't escape.
- The gravity of a black hole is different from normal gravity. No, same gravity.
- The sun – and all other stars – will turn into a black hole. No, just very rare, massive stars.
- Black holes are giant cosmic vacuum cleaners that swallow everything around them. No, only things very nearby, such as gas from a star which is orbiting them.
- Matter (such as you) that falls into a black hole will appear somewhere else in the universe. No, it stays right there.

Supermassive black holes



- Supermassive black holes, millions of times more massive than the sun, are found at the centre of galaxies such as our Milky Way
- We don't know how they formed, so we are looking in young galaxies that are just forming

How astronomers know all this

- We observe and study the stars with telescopes on the ground and in space
- We use scientific knowledge to understand how the stars work

Find out more

- The University of Toronto astronomy outreach website:
- universe.utoronto.ca
- My Education and Outreach webpage:
- www.astro.utoronto.ca/~percy/EPOindex.htm
- Canadian Astronomical Society:
- www.cascaeducation.ca