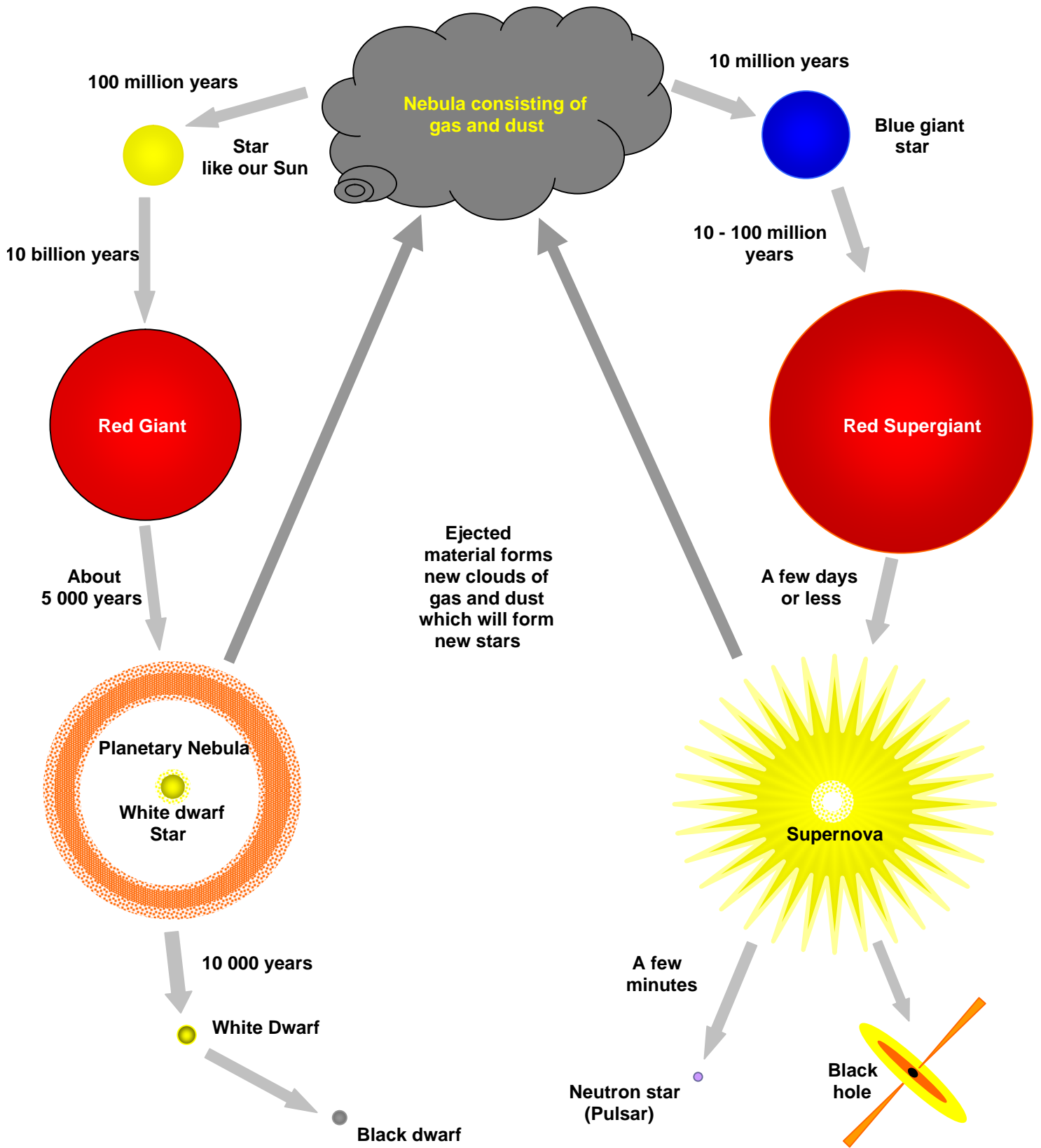


# The Life Cycle of Stars



# Life and Death of Stars

## Stars with a mass similar to that of our Sun

Stars form from large clouds of gas, usually mainly hydrogen, and dust. Stars with a mass about the same as that of our Sun (left hand side of diagram) form fairly slowly. The cloud condenses, gets more and more squashed by gravity, and getting hotter and hotter in the middle at the same time. Eventually the temperature is so high, about 15 million degrees in the centre or core, that the hydrogen in the cloud starts fusing (burning) into helium releasing large amounts of energy. The star reaches a steady state and then continues burning and radiating energy with its surface at a temperature of about 6 000 degrees, for about 10 billion years.

When the hydrogen is used up, the helium starts burning and the temperature rises and the star swells up. As heavier elements, carbon and oxygen, start burning the temperature rises further and the stars swells more. Because the outer layers are now further from the hot centre, they cool a little. Eventually the star has become a **red giant**, with a core temperature of nearly 100 million degrees and a surface temperature of around 3 000 degrees.

It has now got so big that the outer layers of the red giant star are blown away and it then becomes a **planetary nebula**. The bit that's left collapses to a **white dwarf** star. These are about the size of the Earth and extremely dense: a teaspoonful weighing many tonnes! They have a high surface temperature, about 50 000 degrees and slowly cool to become black dwarf stars, no longer visible. The ejected material drifts off into space and will eventually mix with the remains of other stars to form new clouds of gas and dust from which new stars will form.

## Stars with a mass greater than our Sun

Stars with a mass 5 or more times that of our Sun (right hand side of diagram) form from a more massive cloud that condenses forming a **blue giant** star. The process is similar to that of a star like our Sun, but takes a shorter time. Also, because the star is more massive, its core temperature is higher, from 20 to 40 million degrees with a surface temperature of between 10 000 and 40 000 degrees. Because the temperatures are so much higher the hydrogen fuel is burnt much more quickly, giving the star a much shorter life, from about 10 million to 100 million years.

Also because the temperatures are higher, successively heavier elements burn, like Neon, Silicon, Potassium, Calcium and so on, the process stopping when Iron is formed in the core at a temperature of about 10 billion degrees. At this time the star has swelled up to become a **red supergiant** with a surface temperature of about 3 000 degrees. Once the iron has formed, the core cools and the outer layers collapse causing the star to explode in an extremely violent explosion known as a **supernova**. The energy released in a few minutes is more than the Sun has emitted in its life of 10 billion years! For a short time the supernova can be as bright as the entire galaxy in which it is.

Part of the core that is left can form an extremely dense object known as a **neutron star** or **pulsar**. The gravitational forces are so strong that electrons are squashed into the protons forming neutrons. The mass of about 2 Suns or less is squashed into a ball about 20 km across. If there is enough mass after the supernova explosion, more than about 3 times the mass of our Sun, the gravitational forces are so large that the part of the core that is left is squashed into something known as a **singularity** and a **black hole** is formed. The material that is ejected will eventually mix with the remnants of other supernovae and form new stars.

### Some General comments

The above description is very general but does briefly explain how stars are born, live and die. The actual process is far more complex and also very dependent on the mass of the star.

However it is true to say that stars with low masses tend to live longer and tend to end fairly quietly, whereas very massive stars, live for a shorter time and end their lives in a truly spectacular fashion.

The table below gives some indication of relative values mass, temperatures, size and life-span.

<b>Mass (Sun = 1)</b>	<b>Surface Temp. (Degrees C)</b>	<b>Core Temp. (Million Degrees C)</b>	<b>Size (Sun = 1)</b>	<b>Lifetime (Millions of Years)</b>
0.8	5 000	11	0.7	20 000
1	5 750	14	1.0	10 000
1.5	7 250	19	1.4	1 800
2.0	9 250	21	1.6	800
5.0	17 000	27	2.6	80
9.0	24 000	31	3.6	25
15.0	31 000	34	4.8	11
30.0	40 000	37	7.1	6