Ask an Astronomer

Question: "What will happen to the Earth when the Sun dies?"

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Our Sun is a star, just like every other star in the night sky. Stars are just big, spherical nuclear fusion reactors.

The Sun is mostly made of hydrogen atoms. When two of these hydrogen atoms smash together inside the Sun, they form a helium atom, only the helium atom weighs a tiny little bit less than the two hydrogen atoms combined. This "missing mass" has been converted into energy, which shines out into space as sunlight.

Our Sun has been steadily fusing hydrogen into helium for the last 5 billion years, and astronomers predict that it will continue to do the same thing for another 5 billion years, until it runs out of hydrogen. But what happens then? Does the Sun just turn off?

The answer is far more exotic.

Once the hydrogen runs out, the core of helium at the center of the Sun will start to collapse in on itself. As it does so, it gets hotter and denser, until it suddenly starts a second nuclear reaction, turning the helium atoms into carbon and oxygen. At the same time, all this extra energy from the hotter core pushes out the outer layers of the Sun, and the whole thing expands to about 250 times its original size to become a "red giant."

This is pretty bad news for the Earth. There are basically two possibilities: Either the Sun will expand so far that it swallows the Earth whole, in which case it will be destroyed very quickly, or it will expand just enough to leave the Earth intact, while roasting everything on its surface to a crisp. The oceans will boil off, the atmosphere will be blown way, and the surface of the Earth may even get hot enough to turn the rock into liquid magma. Whatever the eventual fate of the Earth, there's no way that anything on it will be able to survive.

So what about the rest of the planets in our Solar System? Mars, Jupiter, Saturn, Uranus and Neptune are far enough away from the Sun that they will probably survive the red giant phase, but the Sun hasn't finished just yet.

Eventually the helium in the Sun's core will run out, in just the same way the hydrogen did. Once again, the Sun's core will collapse, but this time it will never get hot enough to start the next chain of

nuclear reactions. The outer layers of the Sun will get puffed off into space as a "planetary nebula" and the hot carbon and oxygen core will be left, cooling slowly by itself in space.

This dying ember is called a "white dwarf." Although the white dwarf is very hot, it is also very small, and so the light and heat given out by the star will be much less than it used to be.

Any planets that escaped the red giant phase will now be caught in a giant freeze as the temperatures plummet well below freezing.

Here at the Spitzer Science Center, we've been looking at many white dwarfs in our galaxy to see if we can spot the remains of ancient planetary systems that used to exist around the stars before they died. Over the last few years we have discovered dusty disks around many of them, which we think may be the broken-up remains of asteroids left over from the death throes of the system. Although they're too small and too cool to see with our telescopes, the Jupiters and Saturns of these ancient solar systems may still be orbiting around their stars, billions of years after their sun died.

Of course, we don't have to worry about any of this happening during our lifetime -- we have about 5 billion years before we have to pack up and leave. But if human beings last longer than the dinosaurs did, then this is something that our direct descendants will eventually see, and the human race will have to look to the stars to find another place to call home.

For "Ask an Astronomer," I'm Dr. Carolyn Brinkworth for the Spitzer Science Center.