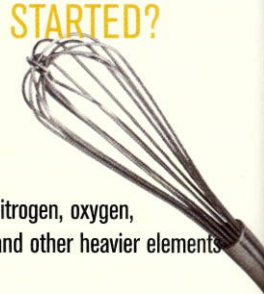
SO YOU WANT TO MAKE A STAR ...

By Karen Kwitter

As the holiday season approaches (look out! Only six more shopping months until Christmas), frustrations tend to rise. What do you get for the person who has everything? And how can you truly show that special someone just how much you care? This holiday season, why not share the gift of astronomy with your loved ones by crafting a star at home? Once you master the basics, you'll be able to create perfect twinkling stars that your family can enjoy for billions of years to come.

HOW DO I GET STARTED?

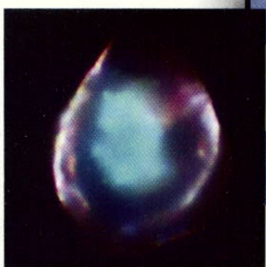


Ingredients:

92% hydrogen
7.8% helium
0.2% mixture of carbon, nitrogen, oxygen, magnesium, silicon, iron, and other heavier elements

Recipe:

It doesn't matter whether you're making a tiny red star for an individual or a larger blue star to please the whole family, the ingredients are the same. Sprinkle them into an empty region of space (a few cubic light years should do) and give things a good stir. Now, retire to a safe distance, say, a light year or two, and watch your star turn on. You'll have to be patient, though; the material you've strewn about needs time to heat up under its own gravity. Preparation time will depend on the mass of the star you're creating: Follow the chart (see Prep Time) for details. Also, make sure you have enough reading material for the wait–a couple of issues of ***mental_floss*** should do the trick.



	BLUE	YELLOW	RED
AMOUNT OF INGREDIENTS	50 x standard	(standard) 10^{57} atoms	1/5 standard
PREP TIME	10,000 years	30 million years	1 billion years
COMPLETED SIZE	large 20 million km radius	medium 700,000 km radius	small 250,000 km radius
LIFESPAN	100,000 years	10 billion years	3 trillion years
ENDS AS	supernova + neutron star or black hole	planetary nebula + white dwarf	dim white dwarf

So, What's Happening Inside My Star?

When prepared as directed, you should end up with a perfectly glowing celestial body. The basic energy-generating process in the star is called hydrogen fusion. Fusion actually takes place in the very core of the star, where four protons (hydrogen nuclei) are transformed into one helium nucleus, with massive amounts of energy being released as a result. This can continue for trillions of years, depending on the star.

How Can I Tell When It's Replacement Time?

Perhaps the most exciting part of making your own star is being there when it reaches its final stage. Once a star runs out of hydrogen to fuse in its core, it begins to change significantly. Don't panic, though; that's how it's supposed to work. Depending on the type of star, the end behavior can be quite different. Here's a breakdown:

Red Star:

A little patience is required to properly view the end of a *red star*, a process that may only occur after trillions of years. In exchange for the long life, the star's last days are quiet and understated. Once it can no longer produce energy in its core, it will contract and eventually become a "helium white dwarf" star. After that, the star will slowly cool and dim after a long and, truthfully, not very exciting existence.

Yellow Star:

It may seem boring to some, but the good old *yellow star* is still the perennial favorite. The combination of formation speed, size and life expectancy makes it popular everywhere.

> "Aside from the very lightest elements (all the hydrogen and most of the helium, lithium, beryllium and boron) that were created in the Big Bang, every single atom in your body was created by a star."

A *yellow star's* fade from glory isn't exactly spectacular, but it's still neat to watch. After the hydrogen is all fused to helium in the core, the outer layers expand while the core shrinks and heats up so much that the helium can now fuse into carbon and oxygen. You can tell that the end is near once the core is all carbon and oxygen because that's when the star develops a case of stellar "hiccups." These hiccups cause the star's outer layers to sporadically blow away, leaving behind a dense, hot core that will eventually become a "carbon-oxygen white dwarf." The resulting star is similar in size and density to a "helium white dwarf" (see *red star* above), but glows with carbon and oxygen on its surface instead of helium. For reference, white dwarfs are about the size of the Earth and a million times denser than lead. So what happens to all those stripped-off layers? Basically, these layers, which have become enriched in

"We had the sky up there, all speckled with stars, and we used to lay on our backs and look up at them, and discuss about whether they was made or only just happened."

— Mark Twain, *The Adventures of Huckleberry Finn*

some of the elements made in the core, form an expanding wreath around the fading white dwarf, known as a planetary nebula, which is eerie-looking but beautiful at the same time.

Blue Star:

The *blue star* is a true Hollywood type—it shines bright, lives fast, and dies young. Even though it's 30 times the size of the standard *yellow star*, it uses up raw materials like they're going out of style and, consequently, is only guaranteed for a 100,000 year existence.

The finale is quite impressive, so don't miss the show. A *blue star*'s core is hot enough to continue fusion beyond carbon and oxygen, generating large amounts of energy and creating successively heavier elements. This keeps going on until, finally, the core is made entirely of iron. Once this happens, no stately wreath is in store for the star; serious star gazers should invest in a nice pair of shades and a tub of sunblock because what you're about to see is a *supernova*. Since it's impossible to wring any more energy out of an iron nucleus, the core undergoes a cataclysmic collapse. In a matter of hours, the outer layers of the star fall in, rebound, and hurtle into space, releasing truly astonishing amounts of energy that momentarily rival the total output of all the two hundred billion stars in the Milky Way Galaxy. Nuclear reactions that couldn't occur previously in the star's core because there wasn't sufficient energy now proceed with abandon in the exploded material. Element creation occurs all the way up to uranium. If you're patient, in a few hundred years you'll see the exploded material expand and glow as a *supernova remnant*. The collapsed core of a supernova can become a *neutron star* (only a few miles across, and a billion times denser than a white dwarf), but in the case of a *blue star*, it will form a *black hole* from which nothing, not even light, can escape.

OK, So What Good are Stars, Anyway?

For the ungrateful few grumbling, "What's a star ever done for me?", here's the short of it. Just take a look at what you're made of: water (hydrogen and oxygen), iron, calcium, potassium, magnesium, copper, and everything else listed on your vitamin bottle. Stars are essentially the recycling engines of the universe, and, aside from the very lightest elements created in the Big Bang, every single atom in your body was created by a star. Everything around you also comes from stars: the gold in your earrings, the aluminum in your soda can and the silicon in your computer chip; it's all stardust.

For the next few billion years, the Galaxy will become progressively richer in all of these recycled elements. But, nothing is forever. More matter is being locked up in stellar corpses (*white dwarfs*, *neutron stars* and *black holes*) than is being recycled to make new stars. And since the raw materials are limited, the process of new star formation should eventually halt. But, can this be the end of the story? Well, don't fret yet. Scientists predict that in about five billion years, our Milky Way Galaxy may collide with the neighboring Andromeda Galaxy, and the collision should trigger a whole new wave of star formation. STOP