Life and the Harmony of the Biospheres

by Margaret Turnbull

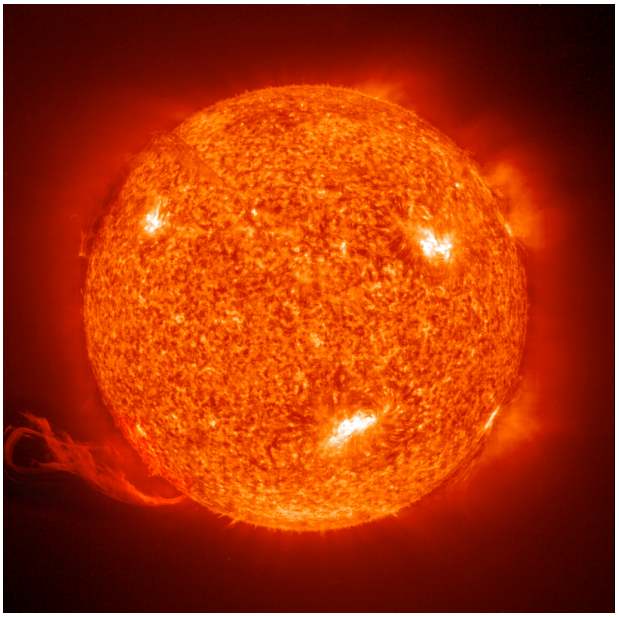
Life on Earth is full. Work, kids, play, exercise, bills, dinner, errands, friends, and family fill our lives with a wild mix of challenge, heartache, comedy, love, boredom and adventure. Given the utmost importance of all this stuff happening within a few miles of home, it's comforting, sometimes, to think about the gigantic context in which our lives unfold.

Everybody knows, for example, that we live on a planet, and that this planet orbits a star which we have named "the sun". And everyone knows that there are eight (or seven) other planets that orbit the sun, along with a slew of moons and little things like asteroids, comets, trans-Neptunian orbiters, Kiuper Belt objects and so on and so forth. And everyone knows that the sun, along with its little pet planets, orbits through a spiral galaxy (which we call the Milky Way), which shines with the light of 400 billion other suns, and is itself moving through the blackness of space along with 100 billion other galaxies, and that this entire universe of galaxies is expanding faster and faster, apparently forever.

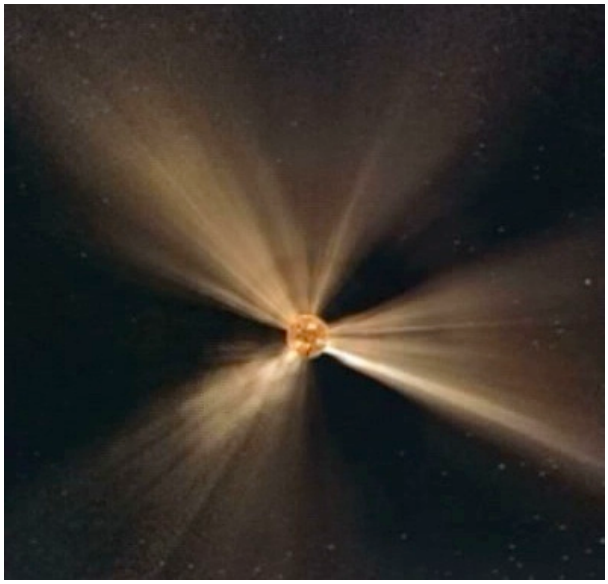
This is common knowledge, fodder for light conversation in elevators. But there is one thing in the universe, a thing at once most important and least understood, which stands out as truly astonishing among all that we've seen: Life on Earth.

The universe changes when it is seen through the lens of life. Trying to understand what it is that has made a bustling civilization of introspective curious creatures possible, we are forced to admit that there are deep, influential, and unseen forces operating in this universe, and I'm not just talking about dark matter. The study of life in the universe, lately known as astrobiology, is carrying all of science into a realm that goes beyond lists of known objects and their constituent components: we have entered the infinite and expanding universe of *relationships.*

The relationships between life and the stars are as complex, beautiful and devastating as any Jane Austin novel. Let's take our own star, the sun, as a happy starting example. If you're a life form, the thing that's so great about the sun is that, for the most part, it can be ignored. The sun, even with its 330,000 Earth masses and one million kilometer radius, emitting the equivalent of 100 billion hydrogen bombs of energy every second, is almost perfectly stable in its brightness. Sure, our star has its little pulsations, flares, cold spots, and coronal mass ejections like anyone. But none of this amounts to more than a few pretty night-time auroras and maybe an occasional satellite re-boot. In fact, I would happily bet everything I own that the Sun will be within one-tenth of a percent of its current brightness tomorrow, next week, and in 1000 years.

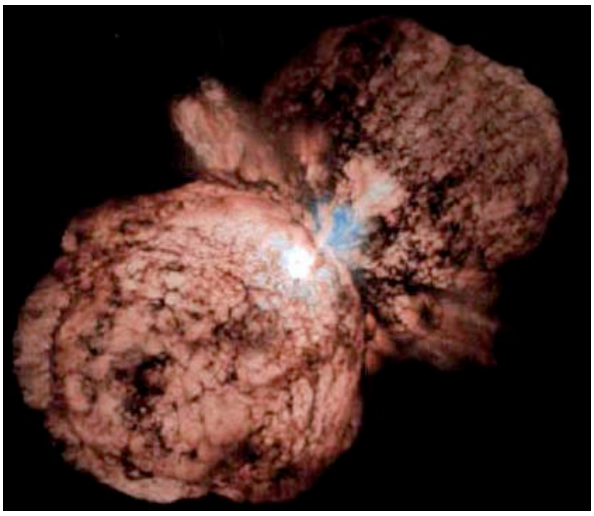


Of course, I intentionally did not say 600 years. The Sun is known to have longer cycles--like the one that warmed up Greenland enough for the Vikings to take over in the 1100s and then cooled off Europe enough for summertime ice-skating in the 1600s. Moving into your next millenium, we can expect a slight warming trend for your next century (not the best time to dump greenhouse gases, folks!), cooling off again as we enter the 2600s (so put that winter coat where you can find it!). These little cycles will come and go, maybe taking a few coastal cities with them, but by and large life on Earth will go on. The simple steadfastness of the Sun, for the past several billion years, is the thing which has allowed life on Earth to take over air, land and sea, and recently, to start learning about the activity of the Sun. Life can handle change, but small and predictable change is greatly appreciated.



What if our star did not have such an even temperament? This is where we begin to see Goldilocks' Law Of Life As We Know It: just as our planet sits in the habitable zone around the Sun where the temperature is just right for liquid water upon which all life depends, so our star seems to be the right size where long term stability is possible. Littler stars, called red dwarfs, account for most of the stars in the Galaxy. But having a red dwarf as your sun is a lot like enjoying a campfire with class B special fireworks embedded in the logs. They randomly emit huge fiery flares, singeing

any planets huddling close enough to keep warm. Forget about re-booting satellites. There will be no satellites. Nevertheless, let us not underestimate the adaptive creativity of life. Underground life, underwater life, life on the planet's night side, life with a coat of armor, and life that knows how to hide real fast, could survive. Maybe not the best real estate in the Galaxy, but certainly not hopeless.



For stars *bigger* than the sun, things are vastly worse. The sun is not by any means huge, but it turns out that stars even just a few times more massive are shockingly short-lived. True, they have more hydrogen to burn, but their fusion engines run so hot that they use up all of their hydrogen fuel even before the planets around them finish forming! At that point, these stars become tremendously unstable, shedding mass left and right as they swell millions of times larger and begin fusing heavier elements like helium, carbon, oxygen, nitrogen, and so on. Impressive, yes, but in my estimation life has no business hanging around in neighborhoods like that.

Still, lest we feel isolated from our neighbors, there is a deep and lovely story to tell, a secret about the relationship between these massive stars, their smaller sun-like counterparts, and life like ourselves.

The story goes like this: As we all know, the universe was born in light and light alone. According to physics, out of this pure energy precipitated a few wisps of hydrogen and helium--but not much out of which to make anything we generally need. Then, a neat thing happened: stars were born. As the first stars condensed from these clouds of hydrogen, their centers ignited in fusion reactions that turned hydrogen into helium, and helium into oxygen, carbon, nitrogen and ever-heavier elements, making nickel and silicon and so on, all the way up to iron. Then those stars exploded, scattering to the winds every element known. Thus was our Galaxy, and every galaxy, seeded with the elements that became incorporated into new stars, and into the first planets orbiting those new stars, and--at least once--into life.

Alas, even our safe harbor around the Sun can't last forever. According to physics we can expect all this friendly stability to come to a crashing end in either 2 or 5 billion years, depending on how smart we are. The Sun still has enough hydrogen fuel to continue stably shining for about 5 billion years before it swells up into a red giant and engulfs the terrestrial planets. However, the Sun has been, and will continue to be, getting slowly ever brighter. Right now, the Earth sits quite near the inner edge of the Sun's habitable zone, and that zone is moving outward as the Sun brightens. Within about 2 billion years, it will be high time to leave our precious blue dot, and Mars may be our next best bet for a good home. Setting up shop on Mars could buy us quite a lot of

time, actually, even another 3 billion years. After that, the moons of Jupiter or Saturn could offer temporary shelter from the swelling red giant Sun. At that point we'd better have a plan for relocation to another planetary system, so as to watch the Sun slough off its outer layers to become a white dwarf with a gorgeous multi-colored nebula--a fitting end to a beautiful life, but a performance best seen from afar.

But what could be the purpose of all of this? What is the grand lesson of this story? That the heavens and earth, and even physics itself, are ephemeral? Wherein is to be found any lasting joy, and where is one single thing that will not ultimately be put to dust? Theories of creation come and go, but can there be a better, higher purpose than to find out what we truly are, and to love being it? Perhaps humanity has a long way to go before grasping the true nature of things, but this quest, I always say, makes us better people--more interesting, more circumspect, more humble, more in tune with the gift of life and the place where we live. That astronomy, let alone astrobiology, even exists as a legitimate profession reveals a widespread love for the universe--not because humans are "hard-wired" to think that the universe is neat, but because the infinite universe of relationships--of being itself--simply *is* lovely, and as conscious beings, we know it.