



## Refining the Goldilocks Zone

### BioUpdate Foundation

Recently I was lucky enough to have an article published in Popular Astronomy, the magazine published by the UK's Society for Popular Astronomy. It discussed the so called Goldilocks Zone; the zone around a star in which life may be found. It is generally defined as the zone in which liquid water can exist. But is that too broad a definition?

The article sprang from something which BioUpdate Founder Felix Franks once said to me; what makes the earth different to other planets is that water exists in all three phases, solid, liquid and gas. The more I thought about this, the more sense it made. I am not some-one who believes that life arrived on this planet riding on the back of a meteorite, and hence if all three phases of water are linked to the emergence of life, then there must be a link to prebiotic synthesis of macromolecules. Fortunately there is.

Many of you will be aware of the classic experiment of Stanley Miller and Harold Urey who recirculated steam through a primitive atmosphere containing water, ammonia, methane and hydrogen, whilst an electric discharge simulated lightning. After a week, they found that the 'soup' contained several organic molecules including 11 types of amino acid. Amino acids are the building blocks for making proteins. In a lesser known but extraordinary experiment lasting 25 years, Miller showed that both amino acids and nucleobases could be synthesised under freezing conditions. Other authors (Orgel and Biebricher) have demonstrated both the *de novo* synthesis of RNA and also RNA synthesised against a complementary strand, otherwise known as replication! Although it is our common expectation that chemistry slows as temperatures decrease, this is not entirely true. As Felix Franks has demonstrated, under conditions of freeze concentration, reaction rates actually increase.

Thus the liquid/gas phase change may have been important for synthesising amino acids and the liquid/solid change and its associated freeze concentration may have been responsible both for condensation reactions giving rise to polymers and also for the generation of RNA like molecules. There are good reasons for thinking that the first self replicating molecules were RNA like.

Arguably therefore it makes sense that life is more likely on planets where water can exist in all three phases.

It is entirely possible that sustainable life could exist solely in oceans, but a little diversity could help "life" survive natural disasters that may wipe out a single species. Colonisation of land is one way to do this and the hydrological cycle, water evaporating from the oceans, raining onto the land and returning to the sea, is a good way of distributing the molecules of primordial life across a planet. Rudimentary evolution may well be helped by adding a challenge to survival. On Earth, such a challenge is given by the seasons, which result from the tilt of the earth's axis. This tilt is stabilised by the presence of our moon.

So if I want to search for extraterrestrial life, there is a good reason to look for planets in the so called “habitable” or Goldilocks Zone around a star, where liquid water will be found. The search might be more successful if we narrow it down to planets where all three phases of water may be found and some subtle evolutionary pressure has been applied by an axial tilt, very possibly stabilised by a moon or two.

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