## From terraforming to finding aliens, a geophysicist explains

July 9 2014, by David Waltham



Capturing planets for human use. Credit: rudolfgetel, CC BY-NC

The Conversation organised a public question-and-answer session on Reddit in which David Waltham, reader in mathematical geology at Royal Holloway in London, explained what makes Earth so special and what life might look like beyond the Blue Planet.

## How feasible is terraforming (modifying a planet to have Earth-like conditions)?

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I remain to be convinced that terraforming is a good idea. If a planet is sufficiently Earth-like to be transformed into a habitable world for us, it may already have life of its own. That makes the whole area morally difficult. As for whether it is technically feasible, there is nothing which would make it impossible as far as I know.

## What life-supporting characteristic of Earth do you believe to be the rarest in the universe?

Many of Earth's life-friendly properties are probably not that rare. It is the combination that may be rare. If, for example, there are eleven essential properties and one planet in ten has the first, then of these one planet in ten has the second and so on, then only one planet per galaxy will have all eleven properties. The property that particularly interests me is the Earth's long-term climate stability. Since wet planets - that is, those that have liquid water - may be inherently climatically unstable.

## Do you think non-water based life can exist?

It seems sensible to assume that we are a typical form of life rather than an atypical form. Water is a particularly suitable liquid for life (for example, it has a wide range of temperatures over which it remains liquid and is an excellent solvent). Also, water is probably the most common suitable substance in the universe (hydrogen and oxygen being particularly common elements). However, this is an assumption and it may be wrong. The trouble is, if it is wrong, where do we start?

> What would you say is the toughest challenge standing between an inorganic planet and one with intelligence we would recognise?

The real barrier is four billion years of good weather. We only have to look at Venus and Mars to see that initially benign planets can become much less life-friendly as they evolve and either freeze all their water or boil it all off into space.

Having said that, there is also evidence that intelligence is a difficult trick to pull off. It is a surprising coincidence that intelligence has taken almost as long to appear ( $\sim 4$ billion years) as there is time available ( $\sim 5$ billion years between the sun forming and the sun becoming too hot for a sustainable planet). One plausible explanation is that the characteristic time for intelligence is very long. We would naturally only ever experience a rare case where intelligence just happened to evolve unusually fast and "just got in under the wire".

## Where in the solar system do you believe there to be the highest chance of life evolving independent of Earth?

I think the icy satellites of Jupiter and Saturn (for example, Europa and Enceladus) are the most promising locations. They have copious liquid water - more than on Earth - which is probably in contact with mineralrich rocks. The discovery of organisms in the geysers spurting from the poles of Enceladus would be the most exciting scientific discovery of my lifetime and we should send a dedicated probe for this.

## Wouldn't every form of evolved life see their own planet as being particularly hospitable to their own specific form of life?

This is an excellent point. Earth life suits the Earth but is that because the Earth is life-friendly or because life as evolved to fit its
environment? My belief is that it is a bit of both since there are limits to Earth-life's ability to adapt. For example, no organisms are known which are living in the absence of liquid water. So there are limits to how extreme the environment could become without life being wiped out.

## Do you think life on Earth would have evolved significantly differently if we didn't have the moon?

Actually, the really interesting question is "what would have happened if the Moon had been a little bit bigger?" Planets with large moons naturally become axially unstable (causing it too wobble too much and making climate unpredictable). If our moon had been only a little bigger, our planet would have started to become unstable now. I think it is really interesting that our moon is very nearly, but not quite, too big. It suggests that moons might be good for life for some reason but shouldn't be so big they cause axial instability.

## Are there economic benefits to mining heavy metals from asteroids when Earth has an abundance of heavy metals to mine?

I think the main benefit to mining in space is that this may be a more efficient way of building in space itself. It saves lifting all that metal off the surface of the Earth. However getting the resource down to land from orbit is technically very difficult so I am doubtful if it will ever be a resource that is used much by Earth-dwellers.

## So, if the hypothesis 'complex biology on Earth has always been in the verge of near destruction and just got luck' is true, what do we do?

The most imminent dangers are human-caused so the first step is to stop that. Then, in the much longer term, we probably do need to take control but that's looking at time-scales of millions of years. We've got to survive that long (and learn a great deal more) before we could become guardians, rather than a threat, to our planet.

## Would planets around stars with slower life cycles, such as red dwarfs, still suffer a similar fate where the star heats up to make life on a planet unsustainable?

This is a really interesting point. Red dwarfs are ten times more common than sun-like stars and give out fairly steady heat for ten times longer. So, if you were to randomly choose a planet inhabited by intelligent organisms, you should be about one hundred times more likely to choose one orbiting a red dwarf rather than a sun-like star.

The obvious question then is "how come our star is not a red dwarf?". To me, the unavoidable conclusion is that there is something wrong with red dwarfs as desirable real-estate. Red dwarfs are more prone to large flares and planets close enough to them to be warm would probably be tidallylocked so that one side always faces the star. Perhaps these things make red dwarfs less life-friendly.

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