

# Earth

A BRIEF INTRODUCTION TO EARTH'S PLACE IN THE UNIVERSE BY CHRIS SARA

## Foreword,

As astronomers, the only cosmic object we are not able to observe is our home planet, Earth. We had images of the other planets and stars long before we had an image of ourselves. In fact, we once believed Earth to be flat, and some still do. One observation we have made in relation to Earth is that, to our knowledge, we are the only place where life is present. What is very evident however, is that for life to form on a planet, many conditions need to align.

For billions of years Earth has existed in a state of stability, thereby, allowing for the right conditions not only for life to begin, but to allow that life to evolve. Earth is now a lifeboat for many complex lifeforms; in a constant process of evolution to adjust to the ever-evolving planet. Life has endured extinction events and there is doubt it will face many more. The formula for life is much more complex than that of planet building; perhaps life is the Universe's ultimate achievement.

We must face the reality that we have a finite time on Earth, as Earth itself has a finite existence. Ultimately physics and chemistry dictate our Sun must one day die. Although more immediately, the way we are treating Earth today could cause irreversible change. Life will become unsustainable and even the planet itself may not be able to survive the forces of the Universe. Until the end we will be driven to look for other life, and a new home for the only life we yet know.

## Introduction

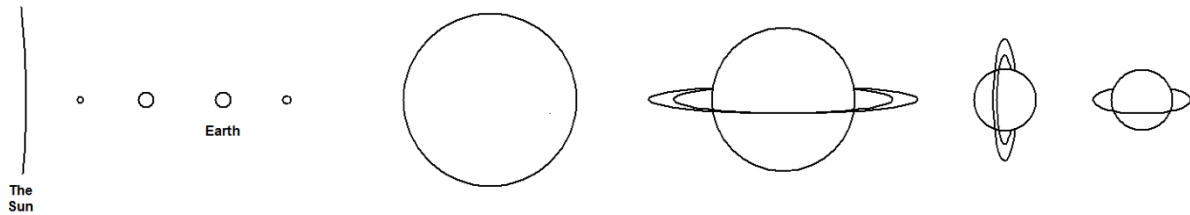
Astronomy is not about looking inwards but it is important to understand ourselves in the context of a greater existence. Our observations illustrate how delicate the balance of life is. We have an obligation to further our existence and to that ends the only solution lays beyond Earth, enviably beyond our Solar System, and into the Universe.

As with everything in the Universe our planets fate will be one of death and absorption, but don't panic just yet, as we are many years from that moment. Life has many opportunities to start many times over, and one day we will no doubt encounter other life, somewhere in the Universe. We are only one of trillions of planets, nestled in billions of galaxies, scattered across the vast expanse of space and time.

This is why it is important to take a moment to reflect on how Earth came to be in the right place at the right time; or as they like to say, "*The Goldilocks Zone*". This is a narrow band of space that exists at a right distance from a right sized sun. A place that has been stable for many billions of years that has the right atmosphere with the right chemical composition. As you factor in all these requirements you quickly come to realise that even with so many planets within the Universe there is still no guarantee that the path of any other planet will mirror that of our Earth.

## Earth

The place we call home, Earth, is quite unlike all the other planets in the Solar System, as in comparison, it is a very peaceful place. Earth provides not only everything we require to live but is our sanctuary in an otherwise hostile Solar System and Universe, that we are separated from, by a mere layer of air.



The planets to scale in size but not in distant from the Sun

### Earth Facts

- We are the third planet from the Sun at an average distant of 150million kms. We refer to this distance as 1AU (Astrological Unit).
- We orbit the Sun every 365.24 days. We have a leap day every 4 years to allow for the 0.24 of a day differential. Every 100 years we skip having a leap year.
- We are the largest of the terrestrial planets with a radius of 6371 kms.
- Our Moon is the largest of all the moons in the Solar System in proportion to its host planet. The Earth Moon relationship plays a critical part in our stability.
- Earth is the only planet not named after a god.

## The Goldilocks Zone

Aptly named for the story of Goldilocks; a girl who wandered into the house of the three bears and found her prefect spot. Earth is in such a zone within our Solar System and this is why life has been able to form.

When all of the conditions required for life are considered it is clear that life formation is truly miraculous. The following conditions give a simplified picture of Earths creation:

### The Right Sun

Foremost, a solar system needs a sun, and our Sun is a good one, where size does matter. If a sun is too big then it will burn itself out, if too small, it will lack the umph to be the life force of a solar system. A suns stability is a balance between gravity and fuel. The greater the gravity the greater the fuel consumption and therefore bigger suns have shorter life spans. Time is an important component in planet formation and even more so for life formation.

The Universe has many suns like ours so this is not the most limiting factor when it comes to the opportunities for life to form.

### Material for Planet Construction

With a suitable sun in place, we now need enough matter to form a planet. Planets are formed from gathering matter as they orbit their sun. A planet needs a critical mass to create a solid inner core surrounded by a liquid outer core. This is the way a magnetic field is generated. If there is not enough material then a large lifeless rock (Planetoid) will be left unfulfilled to orbit until it meets it doom. A number of these objects are present within our Solar System to this day.

## **Magnetic Field**

A planet's magnetic field is generated by the interaction of the molten outer core and solidified inner core. The magnetic field is required to shield a planet from the harmful solar radiation that its sun emits. A planet's atmosphere is also dependent on this. Mars once had an atmosphere that moderated its temperature and allowed water to exist on the surface in a liquid form. Unfortunately, its liquid core cooled and solidified so Mars lost its magnetic field. Solar winds then stripped away the atmosphere and the water froze. Life's opportunity was taken with the atmosphere.

## **Being in the Right Place**

We now have a sun to host a solar system and a planet has formed with a molten core generating a magnetic field. We now require that this planet sits in the right zone of the solar system. This place is a distance that allows the heat of the sun to provide warmth, but not so much that it over heats. Mercury is witness to this. A terrestrial planet like Earth but smaller and far too close to the Sun to give life the opportunity it needs.

An event involving Jupiter, by far the largest planet in our Solar System, influenced the formation of the planets as the Sun dragged it towards the inner Solar System. We define this as the "Grand Tack". This is not a condition of being in the right place but it is an event that contributed to our eventual existence.

## **The Grand Tack**

The dynamics of the Universe are like a giant game of Hungry Hippo. Stuff gobbling stuff to increase mass and gather the fuel required to become something of substance. It is all about gravitational forces attracting matter that eventually collides or orbits in coexistence.

In the early years of our Solar System our Sun had ignited and the planets begun to find their place within this new system. Jupiter was being drawn towards the Sun and collecting everything in and near its path. Through the Asteroid Belt it headed to the inner Solar System consuming much of the available matter that Mercury, Venus, Earth and Mars would need for their formation.

Fortunately, before it could settle in place orbiting much closer to the Sun, the influence of Saturn pulled it back out to where it sits today. This left the inner region to the four terrestrial planets. Mars was left starved of resources and remained smaller than Earth. Sadly, being too small, and further from the Sun, it was robbed of its chance to be Earth Like. Venus had a brief opportunity but a runaway atmosphere meant any chance for life was extinguished. Mercury was far too close to the Sun and never had a real chance and as for the outer planets, well, they have numerous issues that exclude the opportunities for life.

This is an important part of the formation of our Solar System as it influenced many of the conditions needed for Earth to become a host of life. If Jupiter doesn't exist as it does today then the composition of the Solar System would be very different. We have discovered a number of planets orbiting stars and most are more like Jupiter than Earth. They exist at a place that precludes Earth sized planets from forming. Our Solar System could have faced this scenario if Jupiter had not moved back out beyond the Asteroid Belt, meaning life on Earth would not have been possible.

## **Stability**

Even if a planet does manage to meet all of the requirements to create opportunities to host life it is still vulnerable to changes that will affect these opportunities. We have seen this with Venus and Mars. Both were potential life bearing planets only to see their chance snuffed out. The outer giants were never in the mix but Earth held course and won the race to life.

This is due greatly to our stability over many billions of years. A combination of the other planets and the Moon means our orbit is stable around the Sun. Our planet spins at a speed that stops it wobbling off its axis. Our core actively generates a magnetic field that protects our atmosphere. Our atmosphere shields us from the Sun and keeps us warm while burning up small objects that would otherwise pommel our surface. Chemical reactions that are vital to basic life have occurred over these billions of years and now we have evolved into complex lifeforms.

## **Life**

I have very much over simplified the process of planet formation. There are many factors involved as I mentioned, and even if a planet does satisfy them all and get to a point where it does meet the criteria to host life, then life itself has to satisfy an equally complex and highly involved set of criteria. This is a discussion for biologists and not astronomers but it all points to how fortunate we are to have got this far. Whether we are truly capable of appreciating this fact seems at times debatable.

I don't imagine we will ever find life of a "human form", but life of many forms will be present within the Universe. For there to be life like ourselves an evolutionary process along our path would be a miracle<sup>2</sup>, and then we would need to find each other, a miracle<sup>3</sup>. Though, given the miracle that has taken life to this point, and given a Universe of infinite space and time, just maybe, there is another miracle, not unlike us, out there.

## Summary

Astronomy is about looking out and observing the past. A past that formed us and a past that informs the story of our future. We probably take life for granted, but in reality, Earth is not the norm at all. Within all the Universe we are rare, very rare, and that is worth a lot of contemplation and something we need to respect.

We have got this far as a planet and we have many more turns around the Sun to go. Science plots our ultimate fate and we control our immediate future, but if life is to outlast the planet, then we will one day need a new home. We have managed to leave the planet and return, but we will need to go so much further.

Life may be the pinnacle of a planet's evolution, so we could provide those blocks. However, we will need to find a place like Earth, and find a way of getting there, and then restart with very little.

We have started our journey for the survival of life as we define it. But, fulfilling that journey may very well be as miraculous as life's start, billions of years ago.



Maybe the best view an astronomer could ever hope to see