Planet Earth is a warm wet greenhouse volcanic planet. For most of time Earth has had liquid water. Our Earth formed 4600 million years ago from residue from a supernoval explosion and everything on Earth, including you, is recycled stardust. Very early in the Earth's history, it was hit by something very large and the material broken off from Earth ended up in space, this material condensed to form the Moon. In the early history of Earth, from 4600 to 3800 million years ago, planet Earth was bombarded by asteroids and by this method Earth became bigger. All planets get bigger from asteroid and comet impacting and this we have seen with Jupiter when it was hit by the Shoemaker-Levy 9 comet. During the early history of Earth it was very hot, bombardment vapourised any water that had accumulated from comets or hot springs and in this hostile environment, very simple life might have formed only to be vapourised by impacting.

And then, there was a Tuesday 3800 million years ago when something remarkable happened. It rained and running water ran across the land surface, for the first time, and with this rain shower, the atmosphere and land were cool enough and the rain did not turn to steam. Water ran on the surface and moved silt, sand and gravel to deposit sediment, this sediment is still present as sedimentary rocks at Isua in western Greenland and in this sediment is a small amount of carbon that has the chemical signature of life.

This is remarkable, as soon as Earth had permanent liquid water, there was life. This was simple bacteria-like life that could live in an extreme environment and only recently we have been finding extreme life in all sorts of habitats on Earth such as ancient salt deposits where life just stayed there and did nothing for 250 million years, in the ice sheets, in clouds, in cracks in rocks 5 km from the surface, in oil and water in deep wells, in deep ocean hot springs, in surface toxic hot springs and in bogs and swamps. This life needs no sunlight, no oxygen, can survive at high temperature and pressure and just loves toxic chemicals. Even stranger still, chips from oil drilling in the Timor Sea were investigated using a scanning electron microscope, a normal procedure which uses clays to work out whether the rocks were so hot that oil had boiled out from them. These chips of sedimentary rock were hit with a 25 thousand volt electron beam at a high temperature in a vacuum. After scanning electron microscopy, bacteria life that had been trapped in the rock for 235 million years started to grow. This means that some extreme life can survive very high temperature, radiation and a vacuum.

Meteorites from Mars are very rare, there are only about 20 pieces of Mars that have been found on Earth. In 1908, there was a dog in the Egyptian village of Nakhla just doing what dogs do and it was hit by a 2 kg meteorite from Mars. The dog became vapourised and this was the first piece of Martian rock that had been recognised as Martian. Another meteorite from Mars was found in 1984 in Antarctica. It had what looked like fossil bacteria and these had the chemical signature of life. So, if bacteria can survive high temperature, radiation and a vacuum, then bacteria could have been transported from Mars to Earth. As it appears that Mars had water before Earth, life might have formed on Mars before Earth. Life on Earth might have been seeded from

Mars. You might be related to a Martian. As Mars cooled, the liquid iron-nickel core froze and Mars lost its magnetic field and with no magnetic field, the atmosphere and oceans on Mars were blasted away into space and simple bacterial life on Mars might have retreated deep into rocks. There still might be extreme life on Mars. Surface life on Mars would have died and would be preserved as fossils in old hot spring deposits and it is probable that in the next 20 years, fossil life or modern life will be found on Mars. There are other places in our Solar System where life may exist such as underneath the ice in salty water on Europa, a moon of Jupiter.

Early life 3800 million years ago diversified and by 3500 million years ago, colonies of bacteria called stromatolites were in warm shallow waters. This very primitive form of life still exists in warm shallow waters in Western Australia. We have evidence that 2800 million years ago, plate tectonics was in operation, the oceans were being pulled apart (as is happening in the mid ocean ridges today), continents were colliding (as is happening today with Milos formed as a result of Africa colliding with Europe and creating the earthquakes and volcanoes of the Aegean) and continents were being pulled apart (as is happening today in the East African Rift).

Some 2700 million years ago, again on a Tuesday, there was the first great climate change on Earth. The planet became a snowball and the fascinating aspect of this conclusion is that we don't know why we had an ice age. Over the 4600 million year history of planet Earth there have been polar ice caps for 20% of time. We live in one of those unusual times. The end of this ice age stimulated diversity of life and from 2600-2400 million years, one branch of this diverse life pumped out a very poisonous gas. This gas started to accumulate in the atmosphere, this gas started to kill one branch of bacteria called prokaryotes and there was a period of mass genocide of prokaryotes. Some prokaryotes became refugees in bogs, swamps and deep in the Earth and we actually carry these prokaryote refugees in our stomach. It is sobering to be reminded that 90% of our body cells are bacteria, 15% of our weight is bacteria and the largest biomass on Earth are bacteria beneath our feet in soil and rocks. This, of course, raises the philosophical question about what it is to be human if some 90% of our cells are bacterial.

That poisonous gas released by bacteria 2600 -2400 million years ago was oxygen, as oxygen increased in the atmosphere, soils changed colour from green to red-brown, the oxygen content of the oceans increased and, on a Tuesday 2400 million years ago, the oceans rusted. Huge amounts of iron oxide were precipitated on the sea floor and these are now the major iron ore deposits of Australia, Brazil, India, USA and Russia. What happened on that Tuesday 2400 million years ago shows that life, the atmosphere, the oceans and the rocks all interact. This is the story of our planet, the constantly changing interaction between life, the atmosphere, the oceans and the rocks. The bacteria that could survive when oxygen was in the atmosphere and the oceans are eukaryotes, we humans are eukaryotes and we can trace your ancestry back to this Tuesday 2400 million years ago.

Bacteria continued to diversify and 750 million years ago, another extraordinary event took place. The planet became a snowball again. At that time the continents were all at the equator, ice was at sea level at the equator and covered these continents. The rest of the Earth was covered in sea ice and sea level dropped 400 metres and yet, life survived some 50 million years of this very cold period. Then the ice melted, the oceans were at 40 degrees Celsius, a temperature that no ocean has today. Life thrived, great algal limestone reefs formed, sea level rose 400 metres and then the Earth dropped back into being a snowball again. And again, the ice melted, the oceans were heated to 40 degrees Celsius and life again thrived. These were the greatest climate changes that have ever occurred on Earth and, although we have some good ideas, we do not know why we had such climate changes. Nothing has changed, it is the same with the modern climate.

After this ice age, bacteria thrived in warm shallow nutrient rich waters and, on a Tuesday 583 million years ago, multicellular life appeared on Earth. There are places in Australia, Namibia, China and Russia where you can put your finger on the layer where multicellular life first appeared on Earth. There are some 80 known varieties of this multicellular life called the Ediacaran fauna. Some were like jellyfish, others had a backbone and some were covered in a layer similar to that we see on a lobster. They tried every way of eating and locomotion. At 542 million years ago, some of these multicellular organisms extracted carbon dioxide from the seas to form shells, skeletons, scales and spikes. They also extracted oxygen and phosphorus from seawater to form muscles and we had an explosion of life and the Ediacaran fauna quietly became extinct. All major groups of life were formed in this explosion of life which was from 542 to 520 million years ago. However, this was only life in the seas. There was still no life on the land and we have only had life on land for the last 20% of time.

Life on land first appeared 470 million years ago and animals came out of the sea to feed on this new life and then, on a Tuesday 430 million years ago, 75% of life suddenly became extinct. This was the first of the five mass extinctions of multicellular life on Earth. We may be living in the sixth. The evolution of life is interesting, the extinction of life is exciting and we just do not know why 75% of life became extinct 430 million years ago. Life recovered very quickly and there was another mass extinction of multicellular life 360 million years ago. This time, it looks like two asteroid impacts in Sweden led to the extinction. The impact craters are visible, there were massive volcanic eruptions all over planet Earth, the northern hemisphere was swamped by tsunamis, dust filled the atmosphere, there was no sunlight and all vegetation and shallow water marine animals died. Life recovered very quickly.

In the Northern Hemisphere 360 to 300 million years ago, vegetation became very thick and diverse and coal formed. The oxygen and carbon dioxide content of the atmosphere increased to very high levels. The planet enjoyed a warm wet greenhouse and life thrived and expanded. The carbon dioxide in the atmosphere was then 12 times higher than it is now and the oxygen content was 70% higher than now. The

oxygen content was so high that every time there was lightning storm, the atmosphere caught fire, there were massive forest fires followed by a great period of soil erosion. Later from 300 to 251 million years ago, the Southern Hemisphere was at the South Pole and covered in ice, coal formed near the South Pole and there was a desert in the Northern Hemisphere. This was when salt and red sands covered the Northern Hemisphere.

And then, on a Tuesday 251 million years ago, there was another mass extinction, this time 96% of all species of multicellular life became extinct. In Russia 251 million years ago, there was a huge volcanic eruption. This was probably a result of an asteroid impact and the impact crater has been filled with this lava. The Russian volcanoes erupted lava and sulphur-rich gases, these gases combined with water vapour and very acid rain fell. Vegetation was killed, seawater became acid, shallow water marine life died, shells dissolved and animal life on the continents choked. It took 10 million years for life to recover from this, the biggest mass extinction, and we might pause to wonder what might have happened if 100% of all multicellular life became extinct 251 million years ago. The whole process of evolution would have had to start again and would life have ended up the same?

Some 214 million years ago, North America and Russia were hit by a swarm of asteroids. There was another mass extinction of multicellular life on Earth and the continental landmass of Pangea started to break up. Every time a large asteroid hits Earth, there has been a mass extinction of complex life yet simple life such as bacteria survive. Every time a large asteroid hits Earth, there are huge global events of melting and volcanoes and sometimes this is associated with fragmentation of continents. After the mass extinction 214 million years ago, life recovered quickly. In Greece after this mass extinction, limestone, muds, silts and sands were deposited. These rocks now form the backbone of Greece. In some places, such as at Milos, these rocks have later been compressed at very high temperatures and pressures.

About 100 million years ago India pulled away from Australia and moved northwards and Australia pulled away from Antarctica. A minor mass extinction 90 million years ago was caused volcanic gases in the sea and this caused an extinction of life in the deep oceans. The best known mass extinction was 65 million years ago when a large asteroid hit Mexico. Rocks were vapourised into sulphuric acid, the atmosphere was filled with dust and this mixture of white clouds of sulphuric acid and dust blocked out sunlight. When it rained, acid rain killed vegetation, choked life and made the oceans acid thereby killing much of life. Material blasted out from the crater in Mexico fell back to Earth, as it fell it heated until the rocks were red hot and these hot rocks started global forest fires. The planet was covered in dust and charcoal from forest fires and this asteroid impact layer can be found in many places in the world. This was the 5th great mass extinction, the mass extinction that killed the dinosaurs. The main survivors of this mass extinction were deep sea animals and burrowing animals on the land and burrowing mammals, like rats, are your ancestors.

Volcanic gases 55 million years ago poisoned the oceans and some deep marine life became extinct in a minor mass extinction. When India collided with Asia 50 million years ago, the Himalayas started to be uplifted. They are still being uplifted a couple of centimetres a year. This mountain chain divided climates from arid in the north to tropical in the south and the rise of the Himalayas started to change global climate. As rocks rotted to soils, carbon dioxide was extracted from the atmosphere, sediments washed down the big rivers from the Himalayas to the Indian Ocean and carbon dioxide that had been removed from the atmosphere was trapped in ocean floor sediments. For the last 50 million years, the carbon dioxide content of the atmosphere has been decreasing and, as a result, the atmosphere and oceans have been cooling.

When South America pulled away from Antarctica 37 million years ago, a circum polar current isolated Antarctica which froze. Although there was a warm period from 37 to 33 million years ago, there was already ice in Antarctica. In this warm period, the Mediterranean Sea evaporated and thick layers of salt were left of the floor of the Mediterranean. Primates appeared in this warm period over much of Asia, India and Africa. The Mediterranean was again flooded.

However, some 7 million years ago the Mediterranean was again closed at Gibraltar, the Mediterranean again evaporated and sediment as salt was left on the sea floor. Animals from Africa migrated onto the grasslands of what is now the Mediterranean and, when Gibraltar opened again, the Mediterranean became flooded, the African animals moved to higher ground and were isolated on islands. In order to adapt to isolated island conditions with little food, the African animals became smaller. Islands such as Tilos are famous for fossils of dwarf elephants. This year, fossils of dwarf elephants, deer and sheep have been found on Milos.

Meanwhile, global cooling continued and by 5 million years ago, there was an ice cap at the North Pole. Primate forest habitats became grasslands and primates were faced with a choice: become extinct or evolve into something else. Primates did both and one of the evolutionary mechanisms of living in grasslands was to walk on two feet. The primates that did this were humans. The first humans on Earth appeared at this time and in many ways, human evolution was driven by climate change. The humans then were small, robust and there were at least 5 species co-existing at the same place at the same time. Today, we only have one species of human.

Cooling continued and, because Earth was so cool, slight changes in the earth's orbit now had an effect on climate. Climate became cyclical with periods of 90,000 years of cold and 10,000 years of warm and these cycles still exist. When the North Pole became completely frozen 2.5 million years ago, it became much colder. As a result, humans again evolved and we saw our genus *Homo* first appeared in Africa. *Homo* had fire, *Homo* had stone tools and *Homo* had bumps in the skull that suggest that *Homo* could talk. *Homo* probably had the vocabulary of a football player but that did not matter. Because *Homo* could talk, then *Homo* could hunt more efficiently in groups and hunting must have been efficient because there is evidence that older members and those with broken bones were kept alive. Just after *Homo* appeared in

Africa, the movement of Africa northwards into Europe formed large submarine volcanoes on Milos on a Tuesday 2.66 to 1.44 million years ago. Gas streaming through submarine lava at Milos produced pumice that became saturated in water and then sank. Boulders were blasted along the sea floor. The dwarf elephants, deer and sheep that lived on the tidal flats of small islands which were then Milos were choked and fossilised by volcanic ash one and a half million years ago. Water washed their bones onto tidal flats and there they stay. Pumice on the sea floor at Milos was washed around by currents in shallow water and many of these pumice layers contain shallow water fossils. Molten rock pushed its way through the pumice layers and this molten rock was cooled by circulating seawater which leached metals out of the rocks.

In shallow marine basins, precipitates rich in manganese, iron, lead and arsenic were deposited on the sea floor at Cape Vani and these have been lifted some 35 metres above sea level to their present position. Bubbling mud pools and hot springs with extreme life were on the land, there were geysers and steam vents which changed pumice into white kaolin clay, silica, alunite and native sulphur on Milos. Seawater circulating through hot pumice formed bentonite. On Profitas Ilias and Chondro Vouno steam deposited silver and gold 200 metres below the land surface. Later uplift of Profitas Ilias and Chondro Vouno has exposed these silver and gold rich areas at the surface, this uplift was caused by new volcanic intrusions and there were mudflows and perlite intrusions.

Some 125,000 years ago, planet Earth was in one of those 10,000 year periods of greenhouse. Milos at this time was busy with volcanic eruptions. At least four species of humans existed in Africa, Europe and Asia and sea level was 7 metres higher than now and another 90,000-year period of cooling started 118,000 years ago. Large volcanoes such as Toba in Indonesia erupted 74,000 years ago and the dust in the atmosphere did not allow sunlight to enter the atmosphere and the Earth cooled even more. Sea level dropped 130 metres, it became very cold and three of the four human species became extinct about 30,000 years ago. *Homo sapiens* was the survivor.

The peak of the last ice age was only 18,000 years ago and global warming started 14,700 years ago and, since then, sea level has risen 130 metres. There was an intense cold period 12,000-11,000 years ago when ice melt water dams in northern Russia burst. There was warming 11,000 years ago and this was the driving force for the invention of animal husbandry and farming. On Milos, 10,000 years ago there were factories producing obsidian tools which were exported all over the Mediterranean and Asia Minor.

Another cold period from 8,500-8,000 years ago drove people from the Anatolian highlands into the Black Sea Basin which was then grasslands. As global sea levels had risen, the Black Sea remained a grassland basin with two small lakes and the Black Sea Basin was below sea level. The movement of the North Anatolian Fault 7,400 years ago resulted in water rushing in from the Mediterranean Sea into the Black Sea Basin. The Black Sea basin was flooded, villages were inundated and there

are old villages still preserved on ancient shorelines under some 60 metres of water in the Black Sea. This lead to the myth of the Epic of Gilgamesh or the Noah's Flood story of the Bible.

On Milos, the obsidian industry was replaced with clay mining. Over the last 4,000 years, there has been mining on Milos for mill stones for making flour; salt, pumice for polishing; sulphur for agriculture; kaolinite for pottery, ceramics and paper; alunite for dying clothes; bentonite for soap, cleaning, environmental rehabilitation and agriculture; silica for paint; pozzolan for cement; barite for oil drilling; silver for coins and perlite for insulation.

However, geology has not stopped on Milos. Deep beneath Milos are some very hot rocks. Each time Africa pushes into Europe, these hot rocks are strained and they eventually break to produce an earthquake. Seawater has entered these hot rocks and this superheated water at 270 degrees Celsius could be used for geothermal power which is far cheaper than the current diesel-generated power on Milos. Some of this hot water leaks out to the surface to form hot springs. One day, Milos will again erupt as a volcano. The island will slide beneath the sea and what was Milos will be pushed under Europe as Africa joins on to Europe. Don't wait for this to happen, it will take another 10 million years and, of course, will occur on a Tuesday.